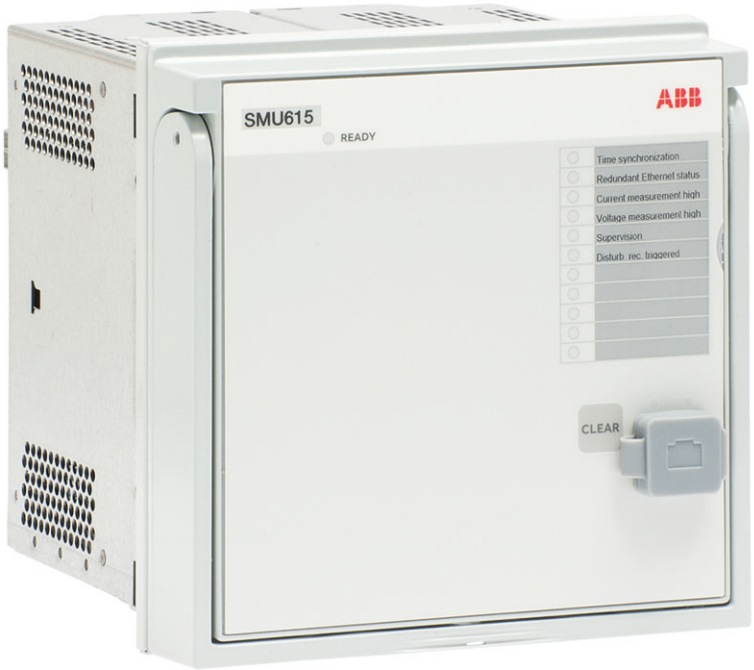
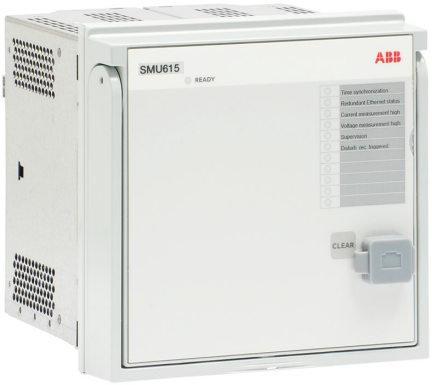
RELION®

Substation Merging Unit SMU615

Application Manual





Document ID: 1MRS758580
Issued: 2022-09-30
Revision: C
Product version: 1.0

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Contents

1 Introduction

1.1 This manual

The application manual contains application descriptions sorted per function. The manual can be used to find out when and for what purpose a typical function can be used.

1.2 Intended audience

This manual addresses the protection and control engineer responsible for planning, pre-engineering and engineering.

The protection and control engineer must be experienced in electrical power engineering and have knowledge of related technology, such as protection schemes and principles.

1.3 Product documentation

1.3.1 Product documentation set

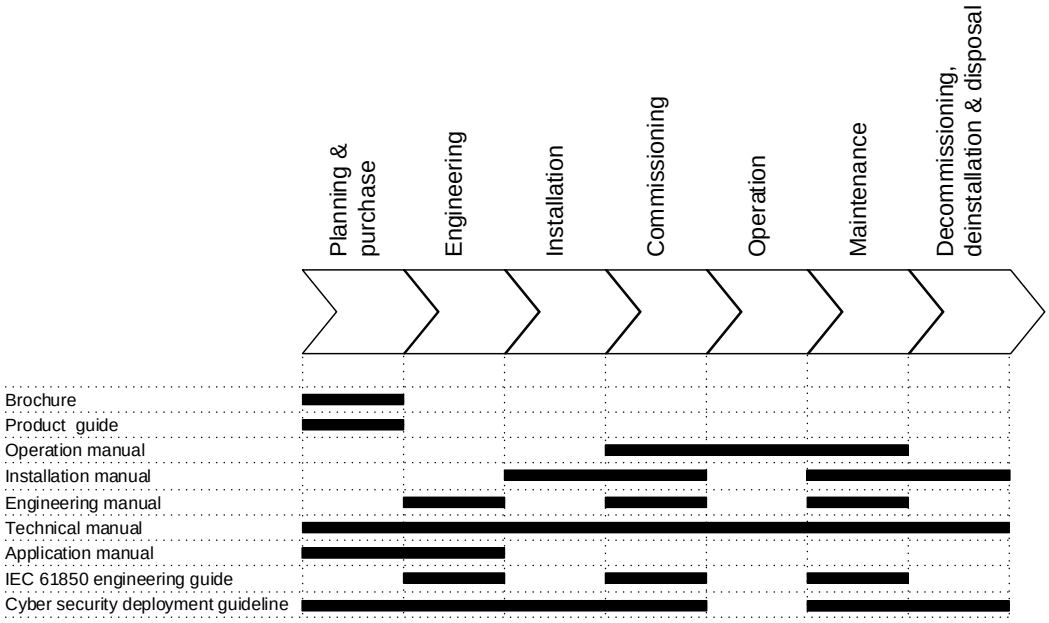

Figure 1: The intended use of documents during the product life cycle

1.3.2 Document revision history

Document revision/date	Product version	History
A/2017-09-26	1.0	First release
B/2019-05-17	1.0	Content updated
C/2022-09-30	1.0	Content updated

1.3.3 Related documentation

Name of the document	Document ID
IEC 61850 Engineering Guide	1MRS758409
Engineering Manual	1MRS758408
Installation Manual	1MRS758405
Operation Manual	1MRS758406
Technical Manual	1MRS758407
Cyber Security Deployment Guideline	1MRS758410

Contact ABB for information on SMU615 related documentation.

1.4 Symbols and conventions

1.4.1 Symbols

The electrical warning icon indicates the presence of a hazard which could result in electrical shock.

The warning icon indicates the presence of a hazard which could result in personal injury.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The information icon alerts the reader of important facts and conditions.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

Although warning hazards are related to personal injury, it is necessary to understand that under certain operational conditions, operation of damaged equipment may result in degraded process performance leading to personal injury or death. Therefore, comply fully with all warning and caution notices.

1.4.2 Document conventions

A particular convention may not be used in this manual.

- Abbreviations and acronyms are spelled out in the glossary. The glossary also contains definitions of important terms.
- Menu paths are presented in bold.

  Select **Main menu** > **Settings**.
- Parameter names are shown in italics.

  The function can be enabled and disabled with the *Operation setting*.
- Parameter values are indicated with quotation marks.

  The corresponding parameter values are "On" and "Off".
- Input/output messages and monitored data names are shown in Courier font.
- This document assumes that the parameter setting visibility is "Advanced".

1.4.3 Functions, codes and symbols

Table 1: Functions included in the merging unit

Function	IEC 61850	IEC 60617	IEC-ANSI
Measurement			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Three-phase current measurement	CMMXU1	3I (1)	3I (1)
Sequence current measurement	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)
Residual current measurement	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
IEC 61850-9-2 LE sampled value sending	SMVSENDER	SMVSENDER	SMVSENDER
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR1	CBCM (1)	CBCM (1)
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCSPVC1	MCS 3I (1)	MCS 3I (1)
Fuse failure supervision	SEQSPVC1	FUSEF (1)	60 (1)
Arc detection	ARCDSARC1	ARCD (1)	AFD (1)
	ARCDSARC2	ARCD (2)	AFD (2)
	ARCDSARC3	ARCD (3)	AFD (3)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)

Table continues on the next page

Function	IEC 61850	IEC 60617	IEC-ANSI
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Other			
Minimum pulse timer (2 pcs)	TPGAPC1	TP (1)	TP (1)
	TPGAPC2	TP (2)	TP (2)
	TPGAPC3	TP (3)	TP (3)
	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC1	TPM (1)	TPM (1)
Pulse timer (8 pcs)	PTGAPC1	PT (1)	PT (1)
	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs)	TOFGAPC1	TOF (1)	TOF (1)
	TOFGAPC2	TOF (2)	TOF (2)
	TOFGAPC3	TOF (3)	TOF (3)
	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs)	TONGAPC1	TON (1)	TON (1)
	TONGAPC2	TON (2)	TON (2)
	TONGAPC3	TON (3)	TON (3)
	TONGAPC4	TON (4)	TON (4)
Set-reset (8 pcs)	SRGAPC1	SR (1)	SR (1)
	SRGAPC2	SR (2)	SR (2)
	SRGAPC3	SR (3)	SR (3)
	SRGAPC4	SR (4)	SR (4)
Move (8 pcs)	MVGAPC1	MV (1)	MV (1)
	MVGAPC2	MV (2)	MV (2)
Generic control point (16 pcs)	SPCGAPC1	SPC (1)	SPC (1)
	SPCGAPC2	SPC (2)	SPC (2)
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)

Table continues on the next page

Function	IEC 61850	IEC 60617	IEC-ANSI
	TRPPTRC2	Master Trip (2)	94/86 (2)
	TRPPTRC3	Master Trip (3)	94/86 (3)
	TRPPTRC4	Master Trip (4)	94/86 (4)
	TRPPTRC5	Master Trip (5)	94/86 (5)

2 SMU615 overview

2.1 Overview

SMU615 is a dedicated substation merging unit intended for measuring current and voltage signals from the instrument transformers and merging them into the standard digital output format that other devices can further use for various power system protection application purposes. SMU615 itself includes no protection functionality but it offers the physical interface into the switchgear primary equipment, that is, circuit breaker, disconnector and earthing switch. SMU615 is a member of ABB's Relion® product family and is characterized by the compactness, simplicity and withdrawable-unit design.

SMU615 has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability in the digital substations. SMU615 supports process bus according to IEC 61850-9-2 LE with IEEE 1588 v2 time synchronization and both conventional CT/VT inputs and sensor inputs.

2.1.1 Product version history

Product version	Product history
1.0	Product released

2.1.2 PCM600 and merging unit's connectivity package version

- Protection and Control IED Manager PCM600 2.7 or later
- SMU615 Connectivity Package Ver.1.0 or later
  - Parameter Setting
  - Signal Monitoring
  - Event Viewer
  - Disturbance Handling
  - Application Configuration
  - Signal Matrix
  - IED User Management
  - IED Compare
  - Firmware Update
  - Lifecycle Traceability
  - Configuration Wizard
  - Label Printing
  - IEC 61850 Configuration

Contact ABB for information on the latest connectivity package.

2.2 Operation functionality

2.2.1 Optional functions

- Arc detection

2.3 Physical hardware

The merging unit consists of two main parts: plug-in unit and case. The content depends on the ordered functionality.

Main unit	Slot ID	Content		Module ID	Details
Plug-in unit	X100	Auxiliary power/BO module		PSM0003 or PSM0004	48...250 V DC/100...240 V AC or 24...60 V DC 2 normally-open PO contacts 1 change-over SO contact 1 normally-open SO contact 2 double-pole PO contacts with TCS 1 dedicated internal fault output contact
	X110			Empty	With application configuration A
		BI/O module		BIO0007	With application configuration B: 8 binary inputs 3 high-speed SO contacts
	X120	Order alternatively options	AI module	AIM0013	3 phase voltage inputs (60...210 V) 3 phase current inputs (1/5 A) 1 residual current input (0.2/1 A)
Case	X130		Sensor input module	SIM0002 or SIM0005	3 combi sensor inputs (three-phase current and voltage) 1 residual current input (0.2/1 A)
	X000	Optional communication module		COM0031 COM0032 COM0033 COM0037	See the technical manual for details about the different communication module types.

Rated values of the current and voltage inputs are basic setting parameters of the merging unit. The binary input thresholds are selectable within the range 16…176 V DC by adjusting the binary input setting parameters.

The connection diagrams of different hardware modules are presented in this manual.

See the installation manual for more information about the case and the plug-in unit.

Table 2: Input/output overview

Appl. conf.	Order code digit		Analog channels			Binary channels	
	8	9-10	CT	VT	Combi sensor	BI	BO
A	A	AA	4	3	-	-	4PO+2SO
A	A	BA/CA	1	-	3	-	4PO+2SO
B	B	AB	4	3	-	8	4PO+2SO+3HSO
B	B	BB/CB	1	-	3	8	4PO+2SO+3HSO

2.4 Local HMI

The LHMI is used for monitoring the merging unit. The LHMI comprises the push button, LED indicators and communication port.

Figure 2: Example of the LHMI

2.4.1 LEDs

The LHMI includes a dedicated Ready LED indicator and 11 matrix programmable LEDs on front of the LHMI.

The LEDs can be configured with PCM600 and the operation mode can be selected via WHMI or PCM600.

2.4.2 Keypad

The LHMI keypad contains a push button which is used to acknowledge alarms.

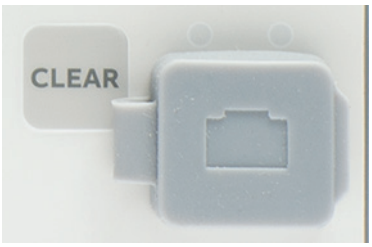

Figure 3: LHMI command push button and RJ-45 communication port

2.5 Web HMI

The WHMI allows secure access to the merging unit via a Web browser. When the *Secure Communication* parameter in the merging unit is activated, the Web server is forced to take a secured (HTTPS) connection to WHMI using TLS encryption. The WHMI is verified with Internet Explorer 8.0, 9.0, 10.0 and 11.0.

WHMI offers several functions.

- Programmable LEDs and event lists
- System supervision
- Parameter settings
- Measurement display
- Disturbance records
- Phasor diagram
- Importing/Exporting parameters
- Report summary

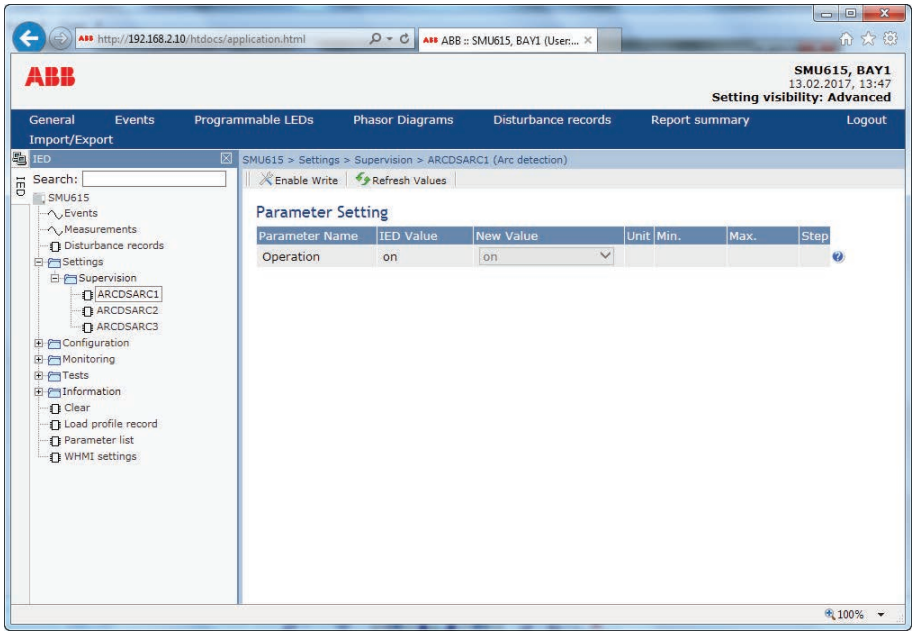

Figure 4: Example view of the WHMI

The WHMI can be accessed locally and remotely.

- Locally by connecting the laptop to the merging unit via the front communication port.
- Remotely over LAN/WAN.

WHMI is enabled by default on the rear port and always enabled (cannot be disabled) on the front port.

If the WHMI is accessed locally via the front communication port, the following features are available.

- Setting the merging unit to test mode and testing of outputs
- Trip circuit lockout reset
- Restoring factory settings

2.6 Authorization

Four user categories have been predefined for the WHMI, each with different rights and default passwords.

The default passwords in the merging unit delivered from the factory can be changed with Administrator user rights.

Table 3: Predefined user categories

Username	User rights
VIEWER	Read only access
OPERATOR	• Clearing indications
ENGINEER	• Changing settings • Clearing event list • Clearing disturbance records • Changing system settings such as IP address, serial baud rate or disturbance recorder settings • Setting the merging unit to test mode • Selecting language
ADMINISTRATOR	• All listed above • Changing password • Factory default activation

For user authorization for PCM600, see PCM600 documentation.

2.6.1 Audit trail

The merging unit offers a large set of event-logging functions. Critical system and merging unit security-related events are logged to a separate nonvolatile audit trail for the administrator.

Audit trail is a chronological record of system activities that allows the reconstruction and examination of the sequence of system and security-related

events and changes in the merging unit. Both audit trail events and process related events can be examined and analyzed in a consistent method with the help of Event List in WHMI and Event Viewer in PCM600.

The merging unit stores 2048 audit trail events to the nonvolatile audit trail. Additionally, 1024 process events are stored in a nonvolatile event list. Both the audit trail and event list work according to the FIFO principle. Nonvolatile memory is based on a memory type which does not need battery backup nor regular component change to maintain the memory storage.

Audit trail events related to user authorization (login, logout, violation remote and violation local) are defined according to the selected set of requirements from IEEE 1686. The logging is based on predefined user names or user categories. The user audit trail events are accessible with IEC 61850-8-1, PCM600 and WHMI.

Table 4: Audit trail events

Audit trail event	Description
Configuration change	Configuration files changed
Firmware change	Firmware changed
Firmware change fail	Firmware change failed
Attached to retrofit test case	Unit has been attached to retrofit case
Removed from retrofit test case	Removed from retrofit test case
Control remote	DPC object control remote
Test on	Test mode on
Test off	Test mode off
Reset trips	Reset latched trips (TRPPTRC*)
Time change	Time changed directly by the user. Note that this is not used when the merging unit is synchronised properly by the appropriate protocol (IEEE 1588 v2).
View audit log	Administrator accessed audit trail
Login	Successful login from IEC 61850-8-1 (MMS), WHMI or FTP.
Logout	Successful logout from IEC 61850-8-1 (MMS), WHMI or FTP.
Password change	Password changed
Firmware reset	Reset issued by user or tool
Audit overflow	Too many audit events in the time period
Violation remote	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI or FTP.
Violation local	Unsuccessful login attempt from IEC 61850-8-1 (MMS), WHMI or FTP.

PCM600 Event Viewer can be used to view the audit trail events and process related events. Audit trail events are visible through dedicated Security events view. Since only the administrator has the right to read audit trail, authorization must be used in PCM600. The audit trail cannot be reset, but PCM600 Event Viewer can filter data. Audit trail events can be configured to be visible also in WHMI Event list together with process related events.

To expose the audit trail events through Event list, define the *Authority logging* level parameter via **Configuration** > **Authorization** > **Security**. This exposes audit trail events to all users.

Table 5: Comparison of authority logging levels

Audit trail event	**Authority logging level**			
	None	Configuration change	Settings edit	All
Configuration change		•	•	•
Firmware change		•	•	•
Firmware change fail		•	•	•
Attached to retrofit test case		•	•	•
Removed from retrofit test case		•	•	•
Control remote			•	•
Test on			•	•
Test off			•	•
Reset trips			•	•
Time change				•
View audit log				•
Login				•
Logout				•
Password change				•
Firmware reset				•
Violation local				•
Violation remote				•

2.7 Communication

The merging unit supports a range of communication protocols including IEC 61850 and IEC 61850-9-2 LE. Operational information and controls are available

through these protocols. However, some communication functionality, for example, horizontal communication between the merging units, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter settings and disturbance recordings can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the IEC 60255-24 standard COMTRADE file format. The merging unit can send and receive binary signals from other devices (so-called horizontal communication) using the IEC 61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. Furthermore, the merging unit supports sending of analog values using GOOSE messaging. The merging unit meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard.

The merging unit can support five simultaneous clients. If PCM600 reserves one client connection, only four connections are left for other clients.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules.

2.7.1 Ethernet redundancy

IEC 61850 specifies a network redundancy scheme that improves the system availability for substation communication. It is based on two complementary protocols defined in the IEC 62439-3:2012 standard: parallel redundancy protocol PRP-1 and high-availability seamless redundancy HSR protocol. Both protocols rely on the duplication of all transmitted information via two Ethernet ports for one logical network connection. Therefore, both are able to overcome the failure of a link or switch with a zero-switchover time, thus fulfilling the stringent real-time requirements for the substation automation horizontal communication and time synchronization.

PRP specifies that each device is connected in parallel to two local area networks. HSR applies the PRP principle to rings and to the rings of rings to achieve cost-effective redundancy. Thus, each device incorporates a switch element that forwards frames from port to port.

IEC 62439-3:2012 cancels and replaces the first edition published in 2010. These standard versions are also referred to as IEC 62439-3 Edition 1 and IEC 62439-3 Edition 2. The merging unit supports IEC 62439-3:2012 and it is not compatible with IEC 62439-3:2010.

PRP

Each PRP node, called a doubly attached node with PRP (DAN), is attached to two independent LANs operated in parallel. These parallel networks in PRP are called LAN A and LAN B. The networks are completely separated to ensure failure independence, and they can have different topologies. Both networks operate in parallel, thus providing zero-time recovery and continuous checking of redundancy to avoid communication failures. Non-PRP nodes, called single attached nodes (SANs), are either attached to one network only (and can therefore communicate only with DANs and SANs attached to the same network), or are attached through a redundancy box, a device that behaves like a DAN.

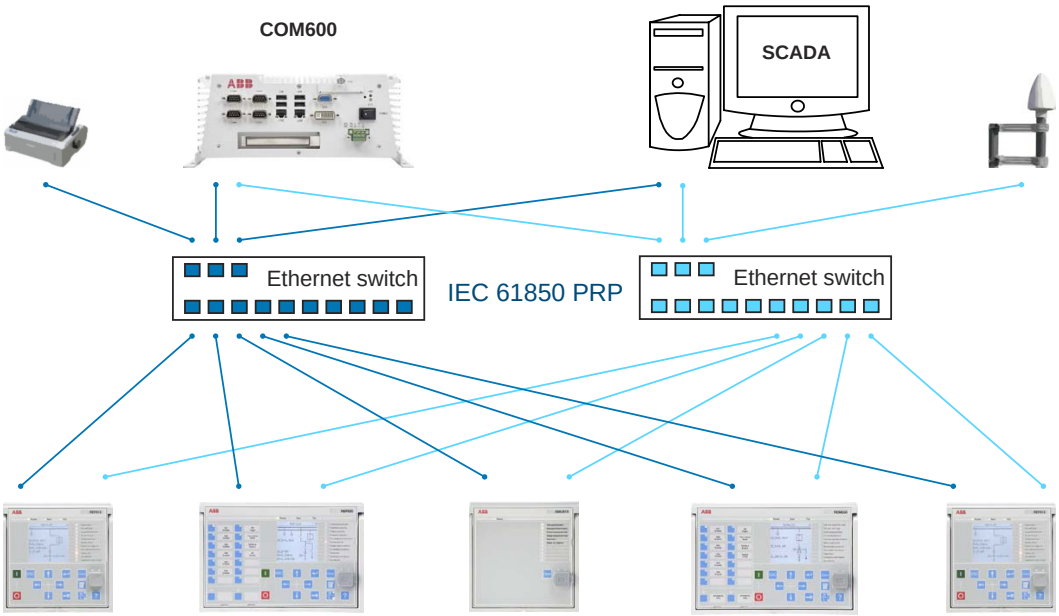

Figure 5: PRP solution

In case a laptop or a PC workstation is connected as a non-PRP node to one of the PRP networks, LAN A or LAN B, it is recommended to use a redundancy box device or an Ethernet switch with similar functionality between the PRP network and SAN to remove additional PRP information from the Ethernet frames. In some cases, default PC workstation adapters are not able to handle the maximum-length Ethernet frames with the PRP trailer.

There are different alternative ways to connect a laptop or a workstation as SAN to a PRP network.

- Via an external redundancy box (RedBox) or a switch capable of connecting to PRP and normal networks
- By connecting the node directly to LAN A or LAN B as SAN
- By connecting the node to the merging unit's interlink port

HSR

HSR applies the PRP principle of parallel operation to a single ring, treating the two directions as two virtual LANs. For each frame sent, a node, DAN, sends two frames, one over each port. Both frames circulate in opposite directions over the ring and each node forwards the frames it receives, from one port to the other. When the originating node receives a frame sent to itself, it discards that to avoid loops; therefore, no ring protocol is needed. Individually attached nodes, SANs, such as laptops and printers, must be attached through a “redundancy box” that acts as a ring element. For example, a merging unit with HSR support can be used as a redundancy box.

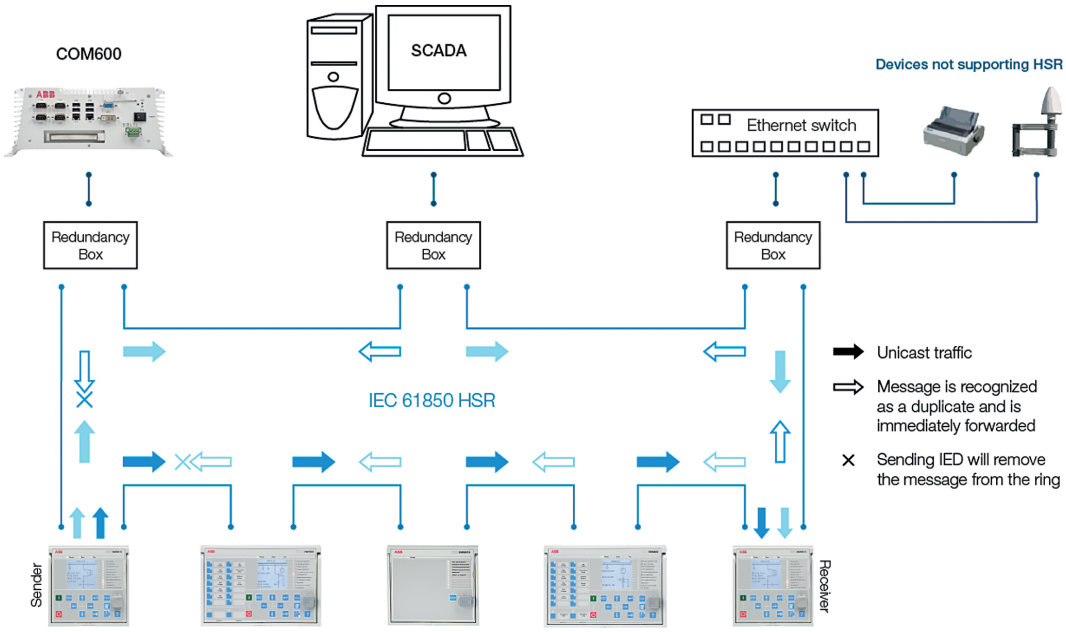

Figure 6: HSR solution

2.7.2 Process bus

Process bus IEC 61850-9-2 defines the transmission of Sampled Measured Values within the substation automation system. International Users Group created a guideline IEC 61850-9-2 LE that defines an application profile of IEC 61850-9-2 to facilitate implementation and enable interoperability. Process bus is used for distributing process data from the primary circuit to all process bus compatible devices in the local network in a real-time manner. The data can then be processed by any protection relay to perform different protection, automation and control functions.

With process bus the galvanic wiring for sharing busbar voltage value can be replaced with Ethernet communication. Transmitting measurement samples over process bus brings also higher error detection because the signal transmission is automatically supervised. Additional contribution to the higher availability is the possibility to use redundant Ethernet network for transmitting SMV signals.

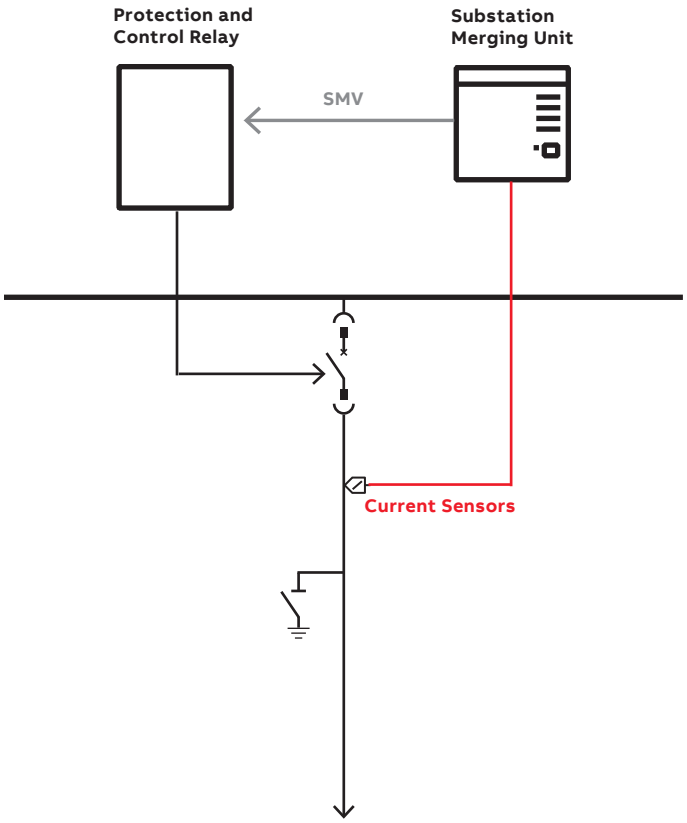

Figure 7: SMU615 sending current measurements as sampled measured values to a protection relay

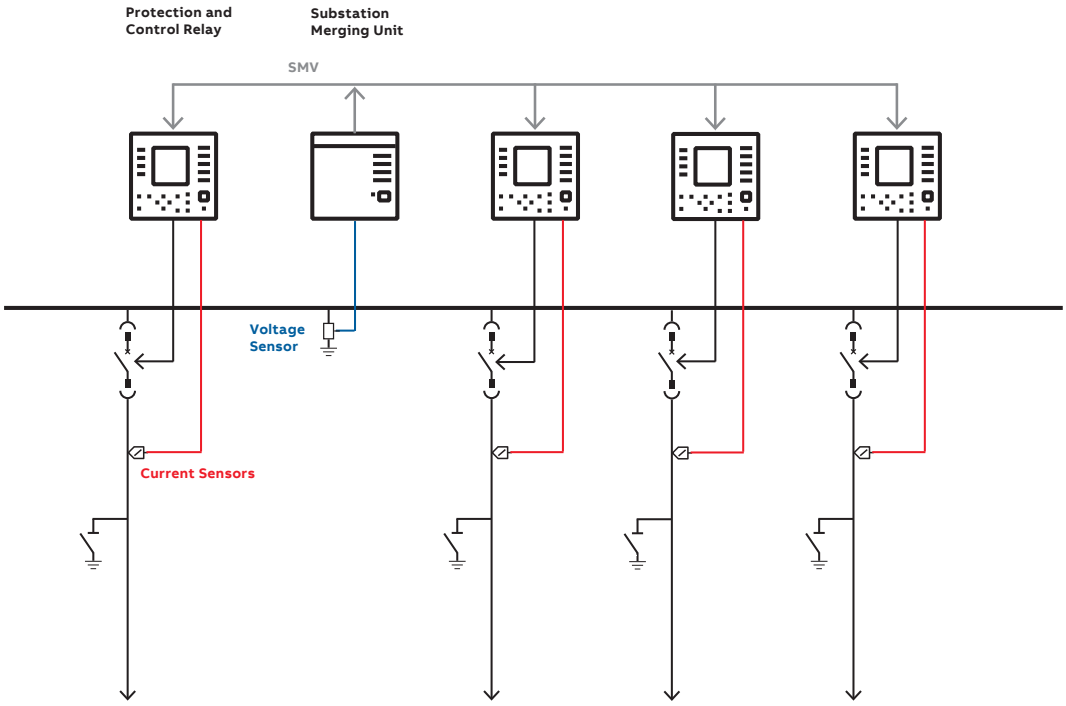

Figure 8: SMU615 sending voltage measurements as sampled measured values to protection relays

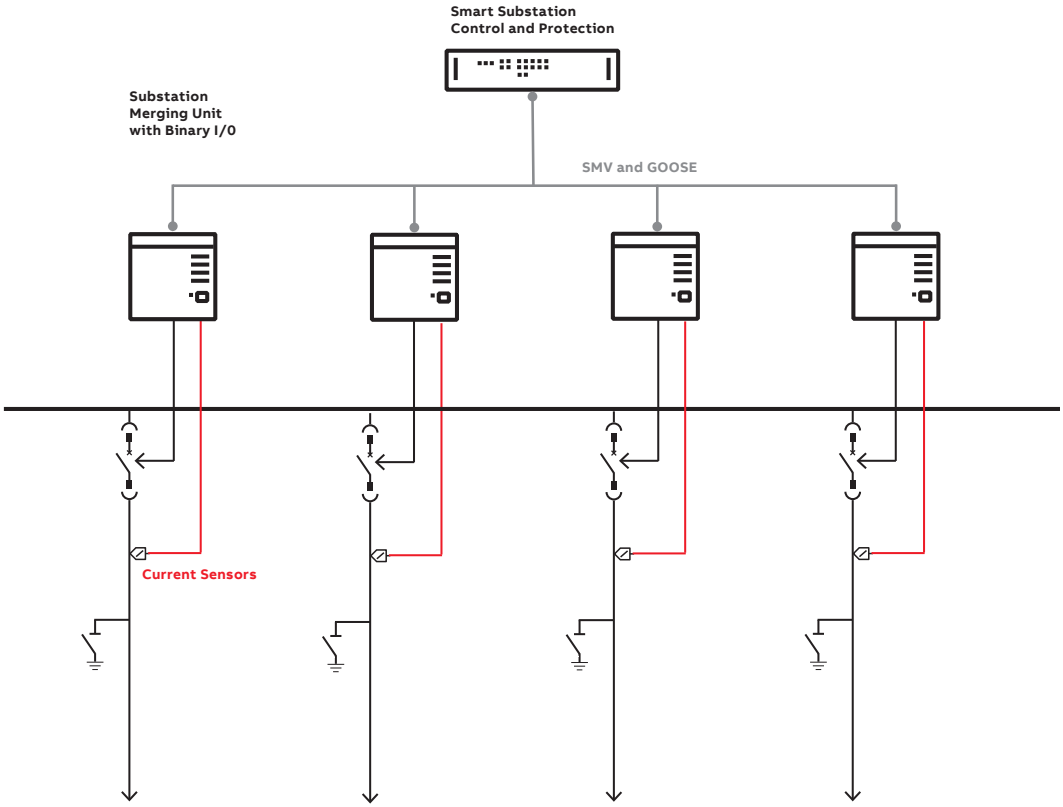

Figure 9: Smart substation control and protection SSC600 with SMU615

The merging unit supports IEC 61850 process bus with sampled values of analog currents and voltages. The measured values are transferred as sampled values using the IEC 61850-9-2 LE protocol which uses the same physical Ethernet network as the IEC 61850-8-1 station bus. The intended application for sampled values is sharing the measured voltages and currents from the merging unit to other devices with 9-2 support.

The merging units with process bus based applications use IEEE 1588 v2 Precision Time Protocol (PTP) according to IEEE C37.238-2011 Power Profile for high accuracy time synchronization. With IEEE 1588 v2, the cabling infrastructure requirement is reduced by allowing time synchronization information to be transported over the same Ethernet network as the data communications.

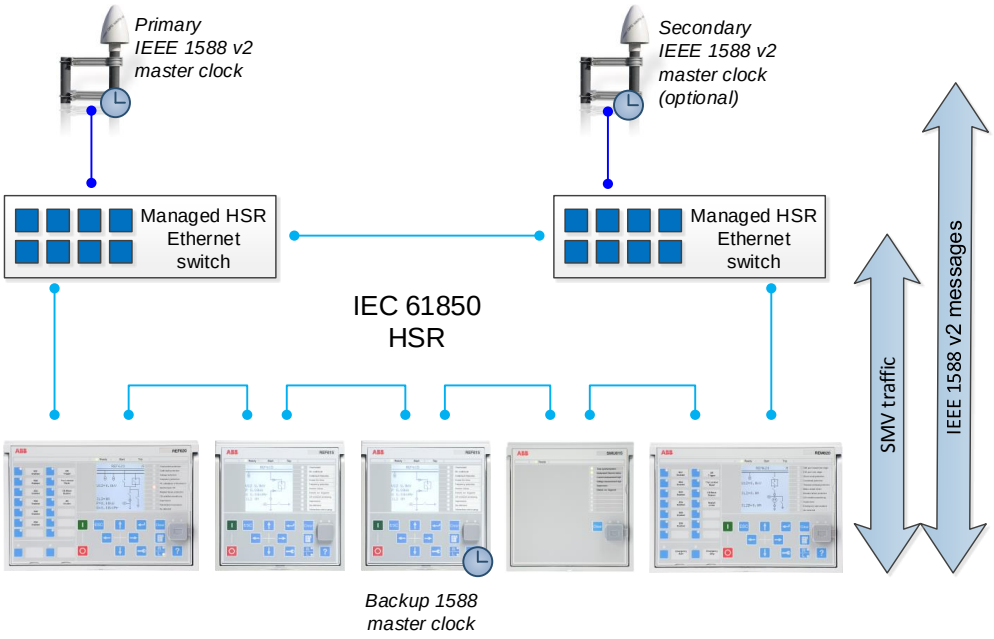

Figure 10: Example network topology with process bus, redundancy and IEEE 1588 v2 time synchronization

The process bus is available for all merging units. See the IEC 61850 engineering guide for detailed system requirements and configuration details.

2.7.3 Secure communication

The merging unit supports secure communication for WHMI and file transfer protocol. If the *Secure Communication* parameter is activated, protocols require TLS based encryption method support from the clients. In this case WHMI must be connected from a Web browser using the HTTPS protocol and in case of file transfer the client must use FTPS.

3 Merging unit variants

3.1 Application configurations

SMU615 is fully configured to perform its designed primary function in the system as a merging unit and it includes only the relevant functions needed for maximum simplicity.

SMU615 is available in two alternative application configurations that can be selected depending on the amount of additional physical interfaces required. Both the application configurations can be selected either with conventional CT/VT inputs or with sensor inputs.

The merging unit is delivered from the factory with a default configuration including its internal connections. System level connections for the sampled measured values (SMV) and GOOSE signals are required between the devices.

Table 6: Application configurations

Description	Appl.conf.
Merging unit with analog inputs	A
Merging unit with analog inputs, binary I/O and remote control	B

3.1.1 Supported functions in SMU615

Table 7: Supported functions

Function	IEC 61850	A	B
Measurement			
Disturbance recorder	RDRE	1	1
Three-phase current measurement	CMMXU	1	1
Sequence current measurement	CSMSQI	1	1
Residual current measurement	RESCMMXU	1	1
Three-phase voltage measurement	VMMXU	1	1
Sequence voltage measurement	VSMSQI	1	1
Three-phase power and energy measurement	PEMMXU	1	1
Frequency measurement	FMMXU	1	1

Table continues on the next page

Function	IEC 61850	A	B
IEC 61850-9-2 LE sampled value sending	SMVSENDER	1	1
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR		1
Trip circuit supervision	TCSSCBR	2 [1]	2
Current circuit supervision	CCSPVC	1	1
Fuse failure supervision	SEQSPVC	1	1
Arc detection	ARCDSARC	(3)	(3)
Control			
Circuit-breaker control	CBXCBR		1
Disconnector control	DCXSWI		2
Earthing switch control	ESXSWI		1
Disconnector position indication	DCSXSWI		2
Earthing switch indication	ESSXSWI		1
Other			
Minimum pulse timer (2 pcs)	TPGAPC	4	4
Minimum pulse timer (2 pcs, second resolution)	TPSGAPC	1	1
Minimum pulse timer (2 pcs, minute resolution)	TPMGAPC	1	1
Pulse timer (8 pcs)	PTGAPC	2	2
Time delay off (8 pcs)	TOFGAPC	4	4
Time delay on (8 pcs)	TONGAPC	4	4
Set-reset (8 pcs)	SRGAPC	4	4
Move (8 pcs)	MVGAPC	2	2
Generic control point (16 pcs)	SPCGAPC	2	2
Master trip	TRPPTRC	2 [1]	5
1, 2, ... = Number of included instances. The instances of a function represent the number of identical function blocks available in the application configuration. () = optional			

[1] Not included in the default application configuration

3.1.2 Addition of control functions for primary devices and the use of binary inputs and outputs

If extra control functions intended for controllable primary devices are added to the configuration, additional binary inputs and/or outputs are needed to complement the standard configuration.

If the number of inputs and/or outputs in a standard configuration is not sufficient, it is possible either to modify the chosen standard configuration in order to release some binary inputs or binary outputs which have originally been configured for other purposes, or to integrate an external input/output module, for example RIO600, to the merging unit.

The external I/O module's binary inputs and outputs can be used for the less time-critical binary signals of the application. The integration enables releasing some initially reserved binary inputs and outputs of the merging unit's standard configuration.

The suitability of the merging unit's binary outputs which have been selected for primary device control should be carefully verified, for example make and carry and breaking capacity. If the requirements for the primary device control circuit are not met, using external auxiliary relays should be considered.

3.2 Connection diagrams

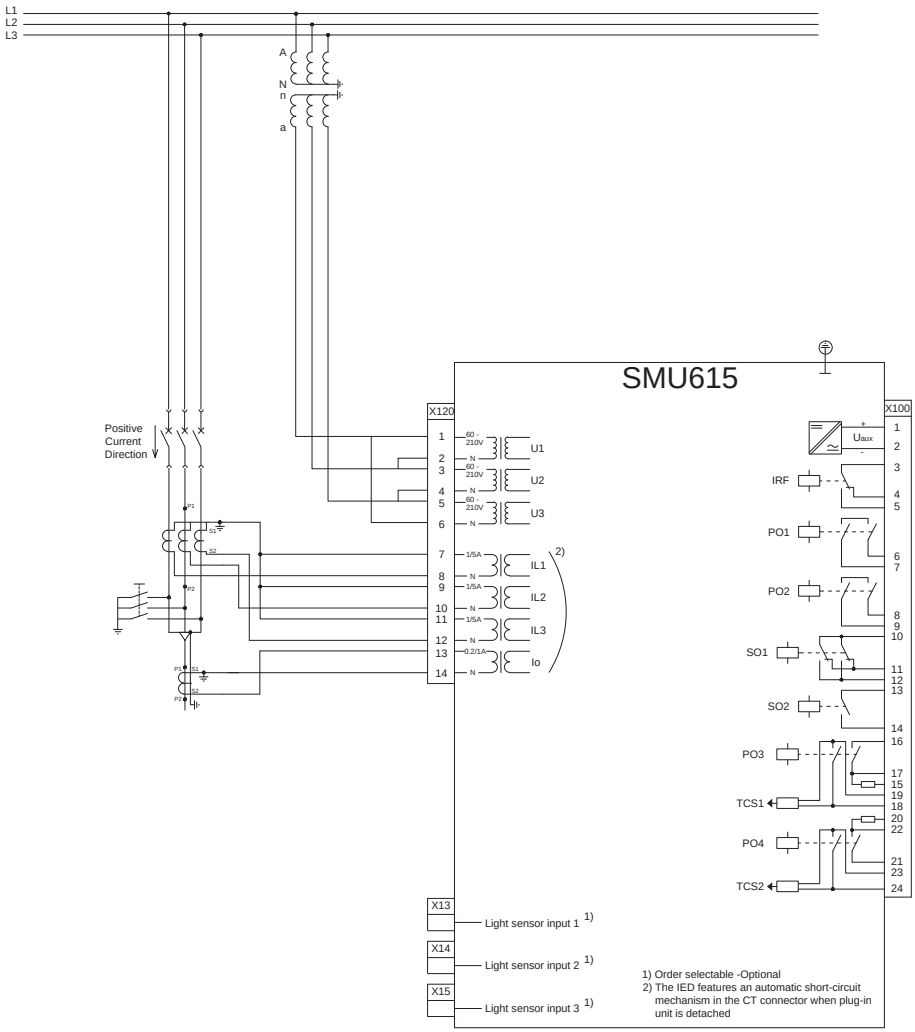

Figure 11: Connection diagram for application configuration A with CT and VT inputs

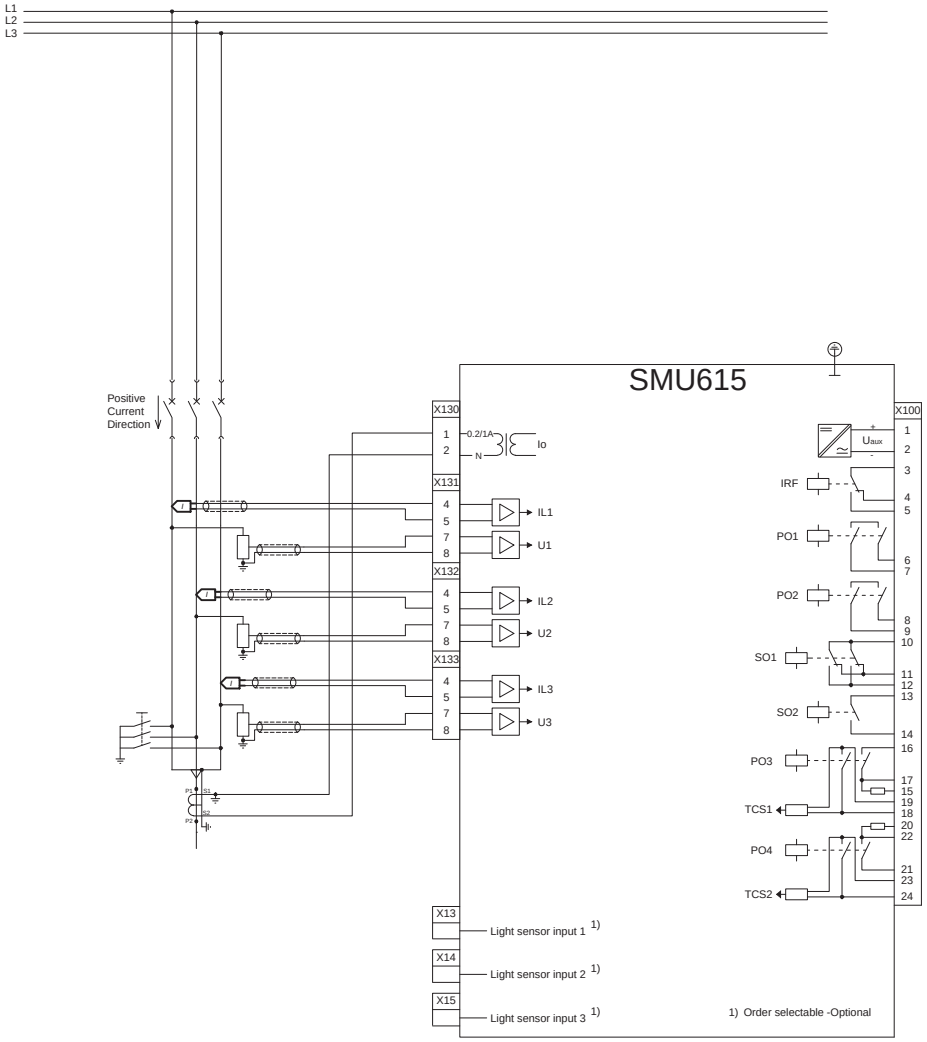

Figure 12: Connection diagram for application configuration A with SIM0002 module

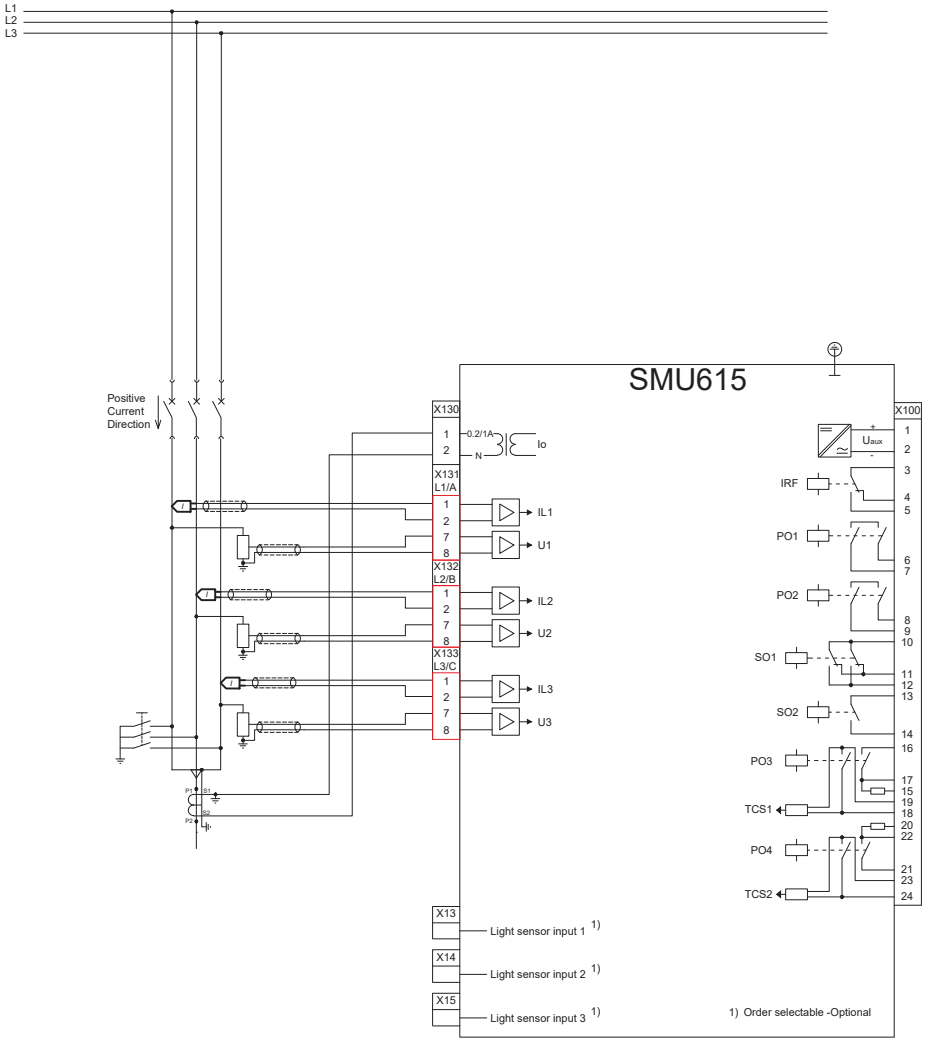

Figure 13: Connection diagram for application configuration A with SIM0005 module

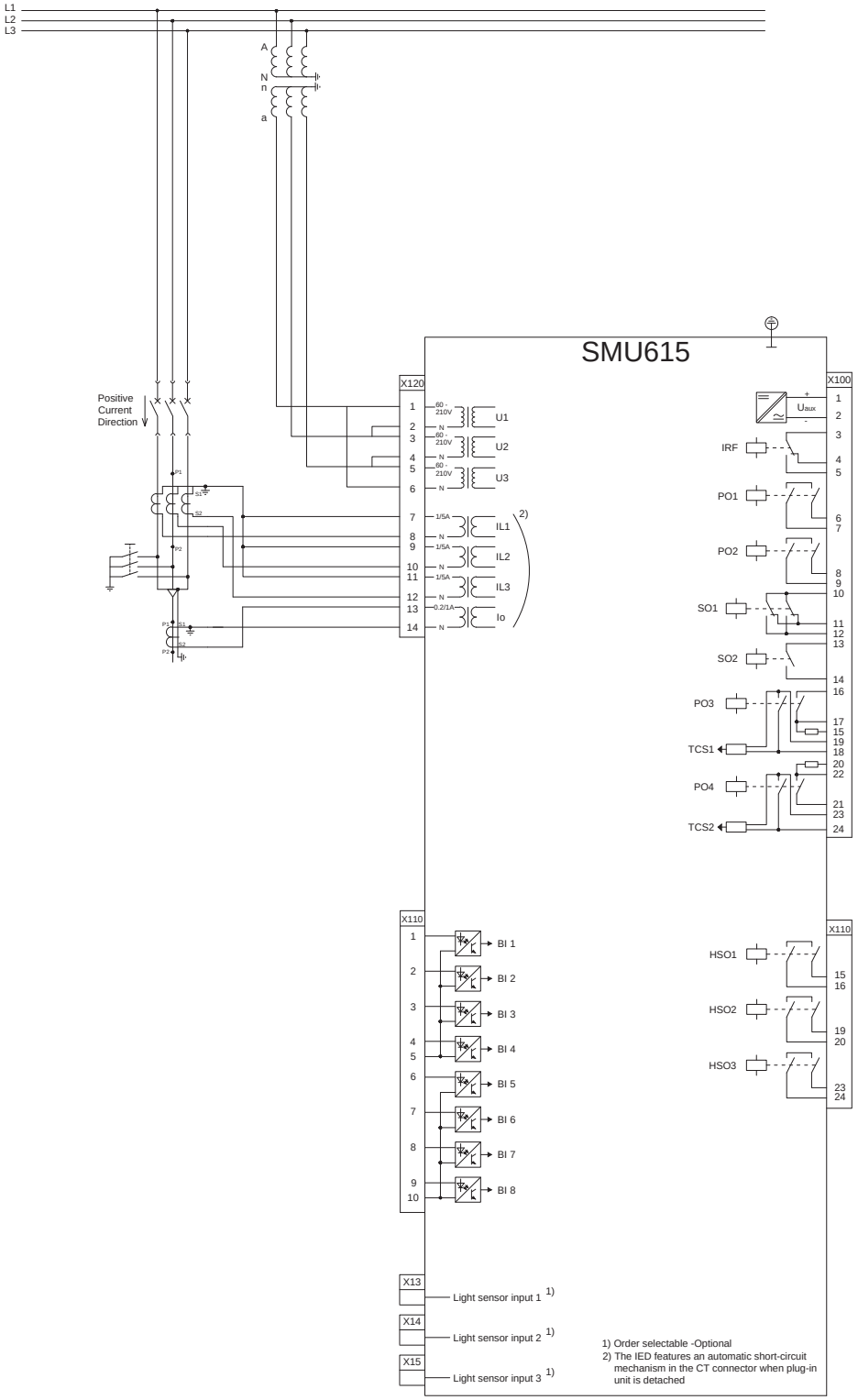

Figure 14: Connection diagram for application configuration B with CT and VT inputs

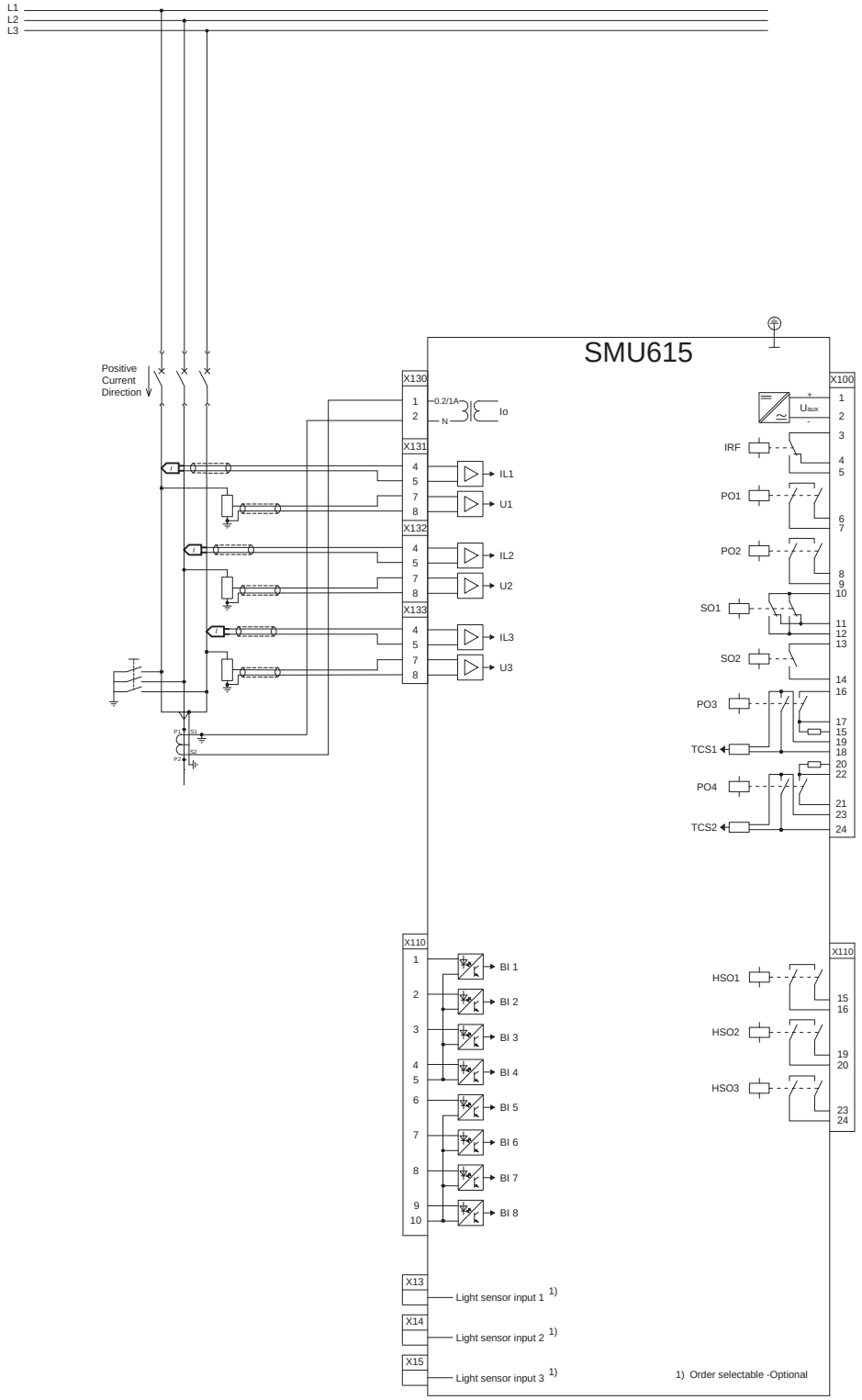

Figure 15: Connection diagram for application configuration B with SIM0002 module

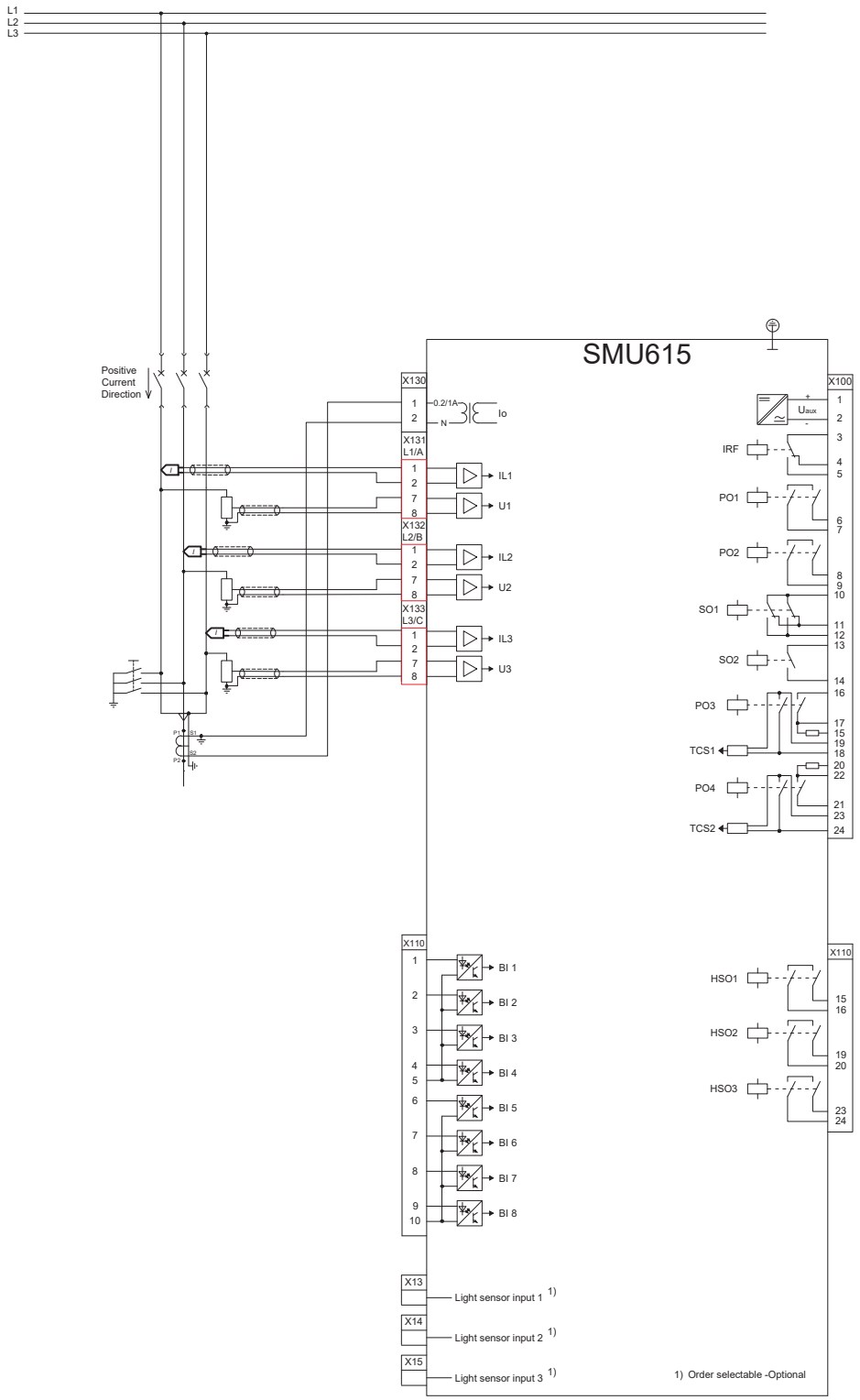

Figure 16: Connection diagram for application configuration B with SIM0005 module

3.3 Application configuration A

3.3.1 Applications

The application configuration A is mainly intended for sharing currents and voltages over the process bus in the digital MV switchgear (main or backup).

The merging unit with an application configuration is delivered from the factory with default settings and parameters. The end-user flexibility for incoming, outgoing and internal signal designation within the merging unit enables this configuration to be further adapted to different primary circuit layouts and the related functionality needs by modifying the internal functionality using PCM600.

3.3.2 Functions

3.3.2.1 Default I/O connections

Connector pins for each input and output are presented in the Merging unit's physical connections section.

Table 8: Default connections for analog inputs with AIM0013

Analog input	Default usage	Connector pins
IL1	Phase A current IL1	X120:7,8
IL2	Phase B current IL2	X120:9,10
IL3	Phase C current IL3	X120:11,12
Io	Residual current	X120:13,14
U1	Phase-to-earth voltage UL1	X120:1,2
U2	Phase-to-earth voltage UL2	X120:3,4
U3	Phase-to-earth voltage UL3	X120:5,6

Table 9: Default connections for analog inputs with SIM0002

Analog input	Default usage	Connector pins
IL1	Phase A current IL1	X131:4,5
IL2	Phase B current IL2	X132:4,5
IL3	Phase C current IL3	X133:4,5
Io	Residual current	X130:1,2

Table continues on the next page

Analog input	Default usage	Connector pins
U1	Phase-to-earth voltage UL1	X131:7,8
U2	Phase-to-earth voltage UL2	X132:7,8
U3	Phase-to-earth voltage UL3	X133:7,8

Table 10: Default connections for analog inputs with SIM0005

Analog input	Default usage	Connector pins
IL1	Phase A current IL1	X131 L1/A:1,2
IL2	Phase B current IL2	X132 L2/B:1,2
IL3	Phase C current IL3	X133 L3/C:1,2
Io	Residual current	X130 I0:1,2
U1	Phase-to-earth voltage UL1	X131 L1/A:7,8
U2	Phase-to-earth voltage UL2	X132 L2/B:7,8
U3	Phase-to-earth voltage UL3	X133 L3/C:7,8

Table 11: Default connections for binary outputs

Binary input	Default usage	Connector pins
X100-PO1	-	X100:6,7
X100-PO2	-	X100:8,9
X100-SO1	Voltage measurement high value warning	X100:10,11,(12)
X100-SO2	Current measurement high value warning	X100:13,14
X100-PO3	-	X100:15-19
X100-PO4	-	X100:20-24

Table 12: Default connections for LEDs

LED	Default usage	Label description
1	Time synchronization status	Time synchronization
2	Redundant Ethernet status	Redundant Ethernet
3	Current measurement high warning	Current measurement high
4	Voltage measurement high warning	Voltage measurement high
5	Secondary circuit supervision alarm	Secondary circuit alarm

Table continues on the next page

LED	Default usage	Label description
6	Disturbance recorder triggered	Disturb. rec. triggered
7	-	-
8	-	-
9	-	-
10	-	-
11	-	-

3.3.2.2 Default disturbance recorder settings

Table 13: Default disturbance recorder analog channels

Channel	Description
1	IL1
2	IL2
3	IL3
4	Io
5	UL1
6	UL2
7	UL3
8	SUo
9	-
10	-
11	-
12	-

Table 14: Default disturbance recorder binary channels

Channel	ID text	Level trigger mode
1	-	-
2	-	-
3	-	-
4	-	-

Table continues on the next page

Channel	ID text	Level trigger mode
5	-	-
6	-	-
7	SEQSPVC1_FUSEF_3PH	Positive or Rising
8	SEQSPVC1_FUSEF_U	Positive or Rising
9	CCSPVC1_FAIL	Positive or Rising
10	-	-
11	-	-
12	-	-
13	-	-
14	-	-
15	-	-
16	-	-
17	GNRLLTMS1_ALARM	Level trigger off
18	GNRLLTMS1_WARNING	Level trigger off
19	SCHLCCH1_CH1LIV	Level trigger off
20	SCHLCCH1_LNK1LIV	Level trigger off
21	-	-
22	-	-
23	ARCDSARC1_ARC_FLT_DET	Positive or Rising
24	ARCDSARC2_ARC_FLT_DET	Positive or Rising
25	ARCDSARC3_ARC_FLT_DET	Positive or Rising
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-

Table continues on the next page

Channel	ID text	Level trigger mode
33	-	-
34	-	-
35	-	-
36	-	-
37	-	-
38	-	-
39	-	-
40	-	-
41	-	-
42	-	-
43	-	-
44	-	-
45	-	-
46	-	-
47	-	-
48	-	-
49	-	-
50	-	-
51	-	-
52	-	-
53	-	-
54	-	-
55	-	-
56	-	-
57	-	-
58	-	-
59	-	-
60	-	-

Table continues on the next page

Channel	ID text	Level trigger mode
61	-	-
62	-	-
63	-	-
64	-	-

3.3.3 Functional diagrams

The functional diagrams describe the default input, output, alarm LED and function-to-function connections. The default connections can be viewed and changed with PCM600 according to the application requirements.

The analog channels have fixed connections to the different function blocks inside the merging unit's application configuration. However, the 12 analog channels available for the disturbance recorder function are freely selectable as a part of the disturbance recorder's parameter settings.

Phase currents are fed to the merging unit from a current transformer or a current sensor depending on the order options. Residual current is fed to the merging unit either from residually connected CTs, an external core balance CT or neutral CT.

Phase voltages are fed to the merging unit from a voltage transformer or a voltage sensor depending on the order options.

3.3.3.1 Functional diagrams for local and remote control

The functional diagrams describe the merging unit's functionality in detail and according to the factory set default connections.

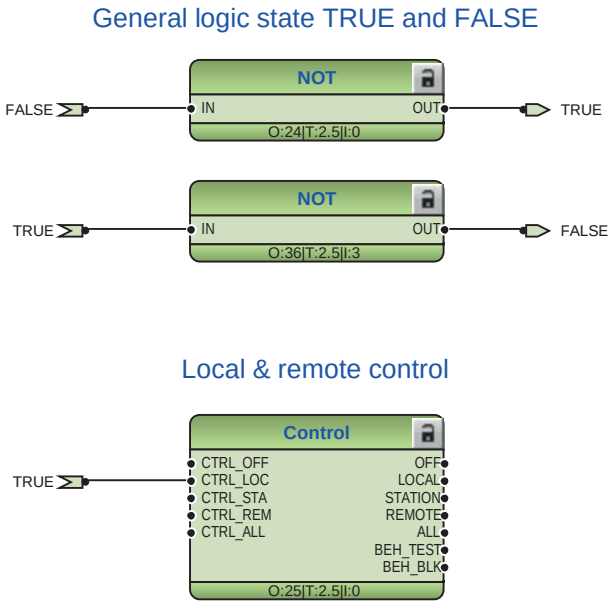

Figure 17: Local and remote control mode function

3.3.3.2 Functional diagrams for disturbance recorder

Output signals from the condition monitoring and supervision functions are routed to trigger the disturbance recorder or, alternatively, only to be recorded by the disturbance recorder depending on the parameter settings. Additionally, the selected signals from different functions are also connected to the disturbance recorder.

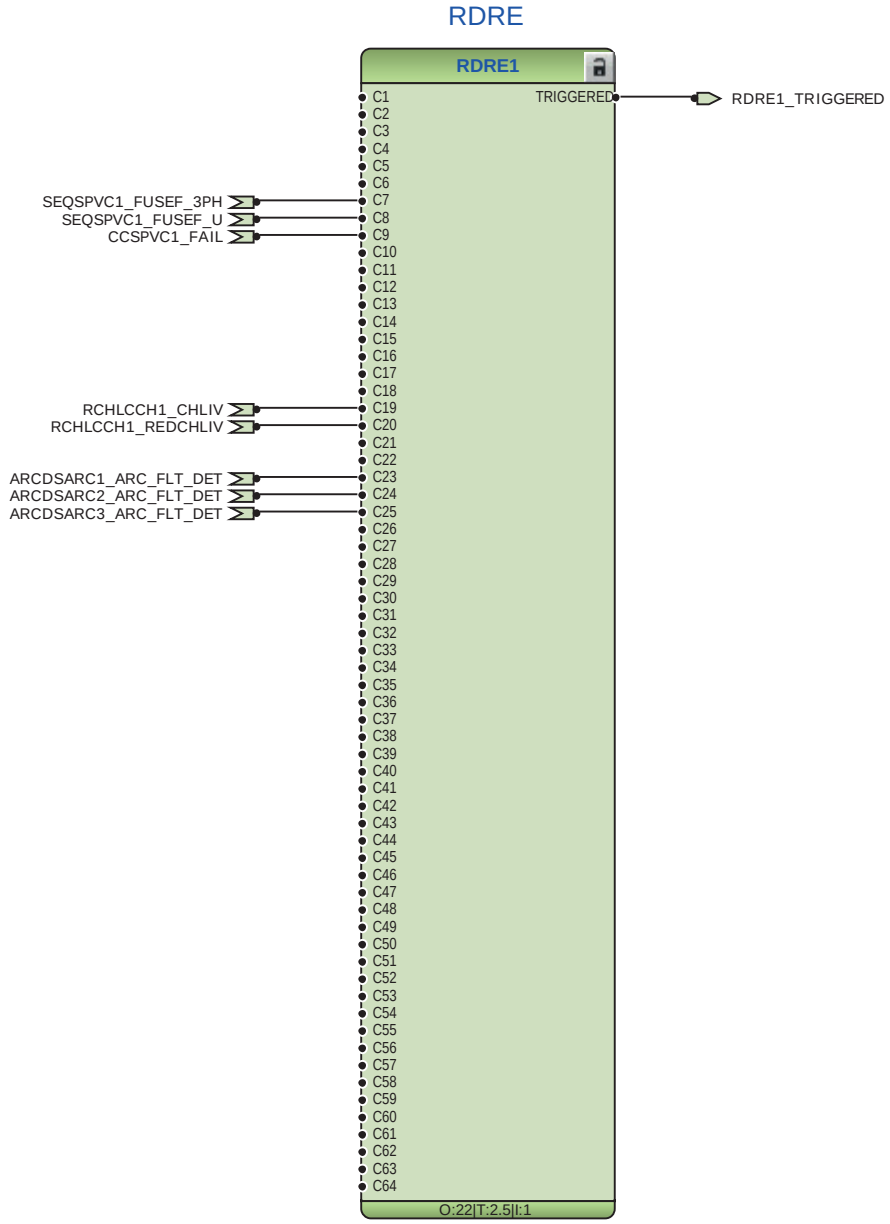

Figure 18: Disturbance recorder

3.3.3.3 Functional diagrams for condition monitoring and supervision

Failures in the current measuring circuits are detected by CCSPVC1.

The fuse failure supervision function SEQSPVC1 detects failures in the voltage measurement circuits. Failures, such as an open MCB, raise an alarm.

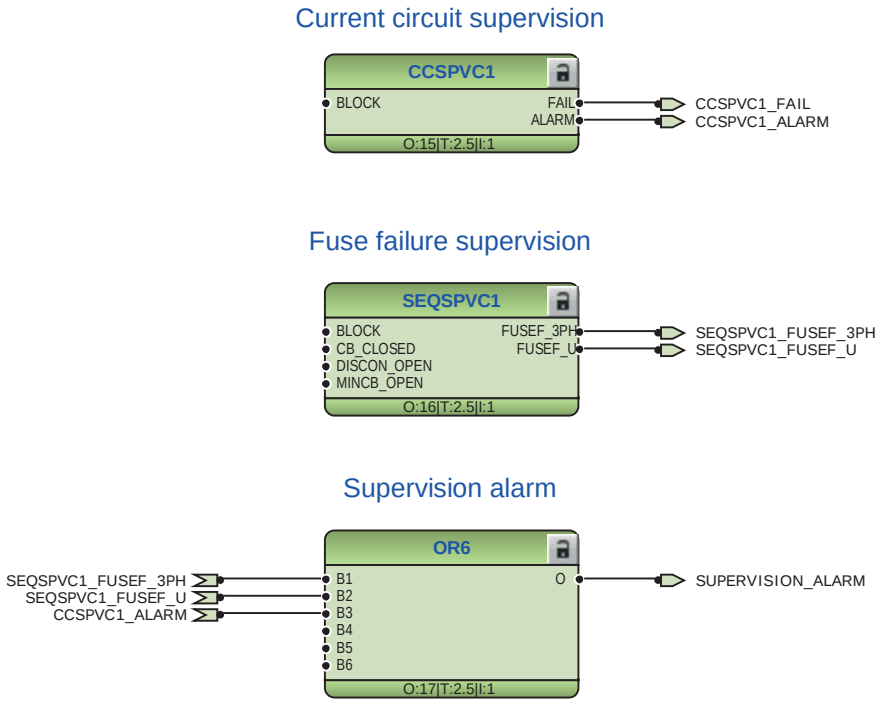

Figure 19: Current circuit and Fuse failure supervision functions

Three arc detection function stages ARCDSARC1...3 are included as an optional function. The arc detection offers individual function blocks for three arc sensors that can be connected to the merging unit. Each arc detection function monitors the light information from an arc and delivers a signal, if an arc is detected.

The output signals from ARCDSARC1...3 are connected to the disturbance recorder function block.

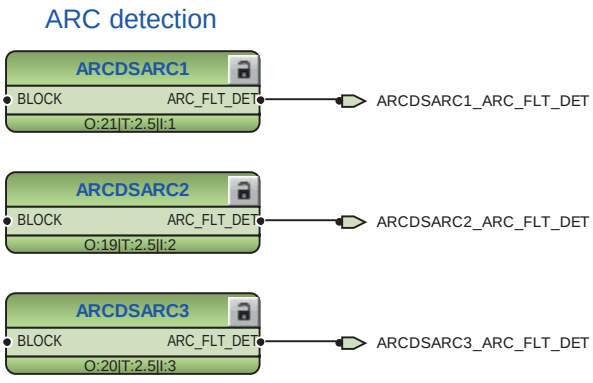

Figure 20: Arc detection function

3.3.3.4 Functional diagrams for measurement functions

The phase current inputs to the merging unit are measured by the three-phase current measurement function CMMXU1. Similarly, the sequence current measurement CSMSQI1 measures the sequence current and the residual current measurement RESCMMXU1 measures the residual current.

The phase voltage inputs to the merging unit are measured by the three-phase voltage measurement function VMMXU1. The sequence voltage measurement VSMSQI1 measures the sequence voltage.

The measurements can be seen from the WHMI and they are available under the Measurement menu in the left navigation bar. Based on the settings, function blocks can generate low alarm or warning and high alarm or warning signals for the measured current values.

The frequency measurement of the power system FMMXU1 and the three-phase power and energy measurement PEMMXU1 are also available.

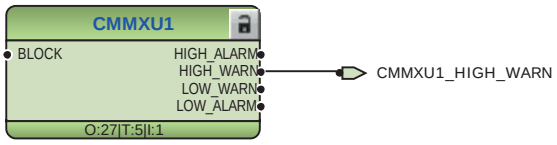

Figure 21: Current measurement: Three-phase current measurement

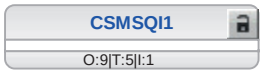

Figure 22: Current measurement: Sequence current measurements

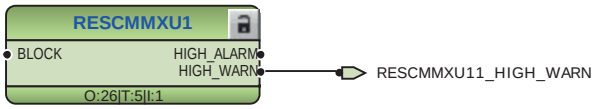

Figure 23: Current measurement: Residual current measurements

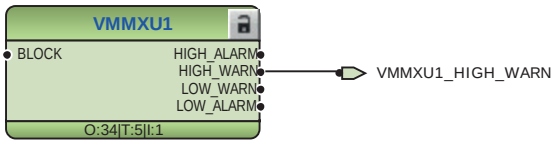

Figure 24: Voltage measurement: Three-phase voltage measurement

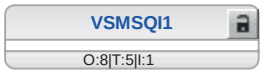

Figure 25: Voltage measurement: Sequence voltage measurements

Figure 26: Frequency measurement

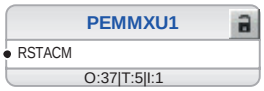

Figure 27: Three-phase power and energy measurement

3.3.3.5 Functional diagrams for I/O and alarm LEDs

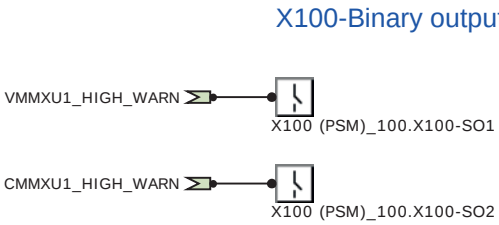

Figure 28: Default binary outputs X100

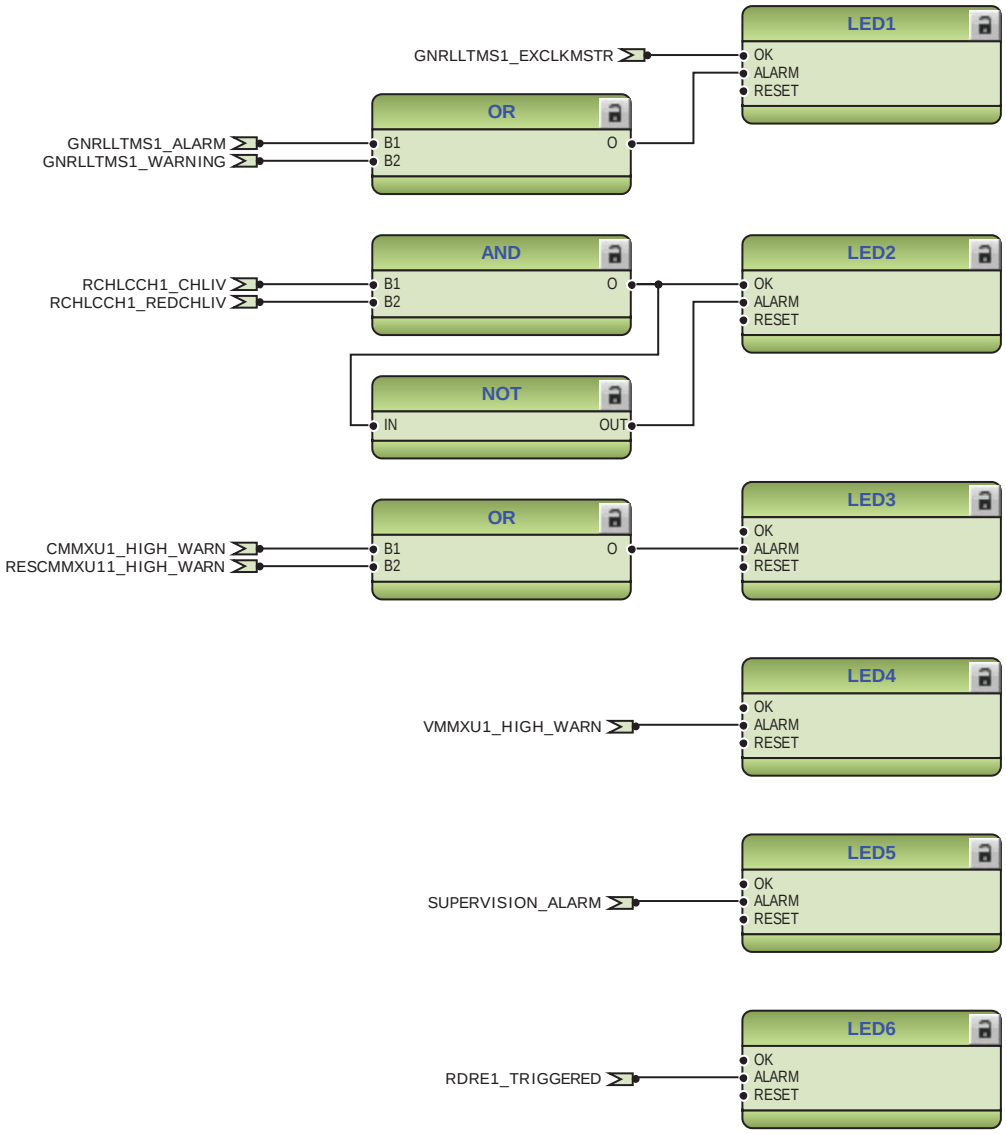

Figure 29: Default LED connection

3.3.3.6 Functional diagrams for communication

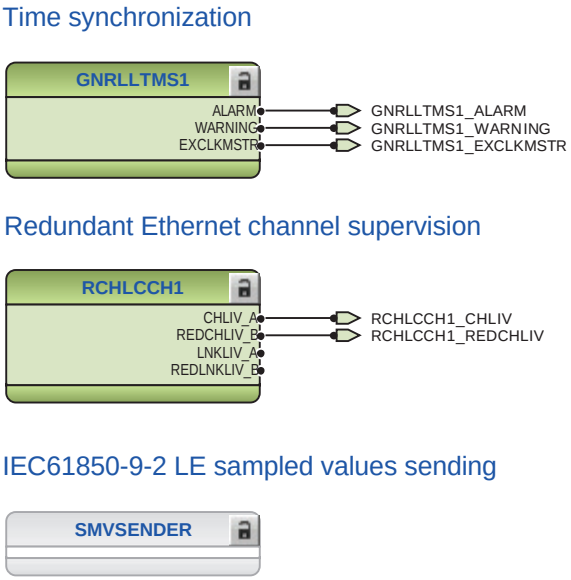

Figure 30: Default communication function connection

The IEC 61850-9-2 sampled values sending is enabled by default.

3.4 Application configuration B

3.4.1 Applications

The application configuration B is mainly intended for sharing currents and voltages over the process bus in the digital MV switchgear (main or backup). Additionally, a merging unit with this application configuration can be used as a breaker control unit (BCU). Application configuration B includes binary inputs and outputs, including three high-speed power outputs for fast tripping. Application configuration B is ready configured for handling GOOSE inputs from two different devices.

The merging unit with an application configuration is delivered from the factory with default settings and parameters. The end-user flexibility for incoming, outgoing and internal signal designation within the merging unit enables this configuration to be further adapted to different primary circuit layouts and the related functionality needs by modifying the internal functionality using PCM600.

3.4.2 Functions

3.4.2.1 Default I/O connections

Connector pins for each input and output are presented in the Merging unit's physical connections section.

Table 15: Default connections for analog inputs with AIM0013

Analog input	Default usage	Connector pins
IL1	Phase A current IL1	X120:7,8
IL2	Phase B current IL2	X120:9,10
IL3	Phase C current IL3	X120:11,12
Io	Residual current	X120:13,14
U1	Phase-to-earth voltage UL1	X120:1,2
U2	Phase-to-earth voltage UL2	X120:3,4
U3	Phase-to-earth voltage UL3	X120:5,6

Table 16: Default connections for analog inputs with SIM0002

Analog input	Default usage	Connector pins
IL1	Phase A current IL1	X131:4,5
IL2	Phase B current IL2	X132:4,5
IL3	Phase C current IL3	X133:4,5
Io	Residual current	X130:1,2
U1	Phase-to-earth voltage UL1	X131:7,8
U2	Phase-to-earth voltage UL2	X132:7,8
U3	Phase-to-earth voltage UL3	X133:7,8

Table 17: Default connections for analog inputs with SIM0005

Analog input	Default usage	Connector pins
IL1	Phase A current IL1	X131 L1/A:1,2
IL2	Phase B current IL2	X132 L2/B:1,2
IL3	Phase C current IL3	X133 L3/C:1,2
Io	Residual current	X130 I0:1,2
U1	Phase-to-earth voltage UL1	X131 L1/A:7,8
U2	Phase-to-earth voltage UL2	X132 L2/B:7,8
U3	Phase-to-earth voltage UL3	X133 L3/C:7,8

Table 18: Default connections for binary inputs when the analog input is equipped with AIM0013

Binary input	Default usage	Connector pins
X110-BI1	Circuit breaker closed position indication	X110:1,5
X110-BI2	Circuit breaker open position indication	X110:2,5
X110-BI3	Circuit breaker truck in (service position) indication	X110:3,5
X110-BI4	Circuit breaker truck out (test position) indication	X110:4,5
X110-BI5	MCB open	X110-6,10
X110-BI6	Control off	X110:7,10
X110-BI7	Earthing switch closed indication	X110:8,10
X110-BI8	Earthing switch open indication	X110:9,10

Table 19: Default connections for binary inputs when the analog input is equipped with SIM0002/SIM0005

Binary input	Default usage	Connector pins
X110-BI1	Circuit breaker closed position indication	X110:1,5
X110-BI2	Circuit breaker open position indication	X110:2,5
X110-BI3	Circuit breaker truck in (service position) indication	X110:3,5
X110-BI4	Circuit breaker truck out (test position) indication	X110:4,5
X110-BI5	-	X110:6,10
X110-BI6	Control off	X110:7,10
X110-BI7	Earthing switch closed indication	X110:8,10
X110-BI8	Earthing switch open indication	X110:9,10

Table 20: Default connections for binary outputs

Binary input	Default usage	Connector pins
X100-PO1	Close circuit breaker	X100:6,7
X100-PO2	-	X100:8,9
X100-SO1	Voltage measurement high value warning	X100:10,11,(12)
X100-SO2	Current measurement high value warning	X100:13,14

Table continues on the next page

Binary input	Default usage	Connector pins
X100-PO3	Open circuit breaker/trip coil 1 (including CBXCBR1)	X100:15-19
X100-PO4	Open circuit breaker/trip coil 2	X100:20-24
X110-HSO1	Master trip 3 (TRPPTRC3)	X110:15,16
X110-HSO2	Master trip 4 (TRPPTRC4)	X110:19,20
X110-HSO3	Master trip 5 (TRPPTRC5)	X110:23,24

Table 21: Default connections for LEDs

LED	Default usage	Label description
1	Time synchronization status	Time synchronization
2	Redundant Ethernet status	Redundant Ethernet
3	Current measurement high warning	Current measurement high
4	Voltage measurement high warning	Voltage measurement high
5	Secondary circuit supervision alarm	Secondary circuit alarm
6	Disturbance recorder triggered	Disturb. rec. triggered
7	Circuit breaker condition monitoring alarm	CB condition monitoring
8	Feeder in service	Feeder in service
9	Feeder out of service	Feeder out of service
10	Earthing switch closed	Earthing switch closed
11	Circuit breaker trip	Trip

3.4.2.2 Default disturbance recorder settings

Table 22: Default disturbance recorder analog channels

Channel	Description
1	IL1
2	IL2
3	IL3
4	Io
5	UL1

Table continues on the next page

Channel	Description
6	UL2
7	UL3
8	SUo
9	-
10	-
11	-
12	-

Table 23: Default disturbance recorder binary channels when the analog input is equipped with AIM0013

Channel	ID text	Level trigger mode
1	CB Closed	Level trigger off
2	CB Open	Level trigger off
3	DC1 Closed	Level trigger off
4	DC1 Open	Level trigger off
5	ES Closed	Level trigger off
6	ES Open	Level trigger off
7	SEQSPVC1_FUSEF_3PH	Positive or Rising
8	SEQSPVC1_FUSEF_U	Positive or Rising
9	CCSPVC1_FAIL	Positive or Rising
10	TRPPTRC1_TRIP	Positive or Rising
11	TRPPTRC2_TRIP	Positive or Rising
12	TRPPTRC3_TRIP	Positive or Rising
13	TRPPTRC4_TRIP	Positive or Rising
14	TRPPTRC5_TRIP	Positive or Rising
15	CONTROL OFF	Level trigger off
16	MCB open	Level trigger off
17	GNRLLTMS1_ALARM	Level trigger off
18	GNRLLTMS1_WARNING	Level trigger off
19	SCHLCCH1_CH1LIV	Level trigger off

Table continues on the next page

Channel	ID text	Level trigger mode
20	SCHLCCH1_LNK1LIV	Level trigger off
21	CBXCBR1_CLOSE_COMMAND	Level trigger off
22	CBXCBR1_OPEN_COMMAND	Level trigger off
23	ARCDSARC1_ARC_FLT_DET	Positive or Rising
24	ARCDSARC2_ARC_FLT_DET	Positive or Rising
25	ARCDSARC3_ARC_FLT_DET	Positive or Rising
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-
33	GOOSERCV_BIN 0_MASTER_TRIP 1	Level trigger off
34	GOOSERCV_BIN 1_MASTER_TRIP 2	Level trigger off
35	GOOSERCV_BIN 2_MASTER_TRIP 3	Level trigger off
36	GOOSERCV_BIN 3_MASTER_TRIP 4	Level trigger off
37	GOOSERCV_BIN 4_MASTER_TRIP 5	Level trigger off
38	GOOSERCV_BIN 5_LOCKOUT_RESET	Level trigger off
39	GOOSERCV_BIN 6_AU_OPEN	Level trigger off
40	GOOSERCV_BIN 7_AU_CLOSE	Level trigger off
41	GOOSERCV_BIN 10_MASTER_TRIP 1	Level trigger off
42	GOOSERCV_BIN 11_MASTER_TRIP 2	Level trigger off
43	GOOSERCV_BIN 12_MASTER_TRIP 3	Level trigger off
44	GOOSERCV_BIN 13_MASTER_TRIP 4	Level trigger off
45	GOOSERCV_BIN 14_MASTER_TRIP 5	Level trigger off
46	GOOSERCV_BIN 15_LOCKOUT_RESET	Level trigger off
47	GOOSERCV_BIN 16_AU_OPEN	Level trigger off

Table continues on the next page

Channel	ID text	Level trigger mode
48	GOOSERCV_BIN 17_AU_CLOSE	Level trigger off
49	-	-
50	-	-
51	-	-
52	-	-
53	-	-
54	-	-
55	-	-
56	-	-
57	-	-
58	-	-
59	-	-
60	-	-
61	-	-
62	-	-
63	-	-
64	-	-

Table 24: Default disturbance recorder binary channels when the analog input is equipped with SIM0002/SIM0005

Channel	ID text	Level trigger mode
1	CB Closed	Level trigger off
2	CB Open	Level trigger off
3	DC1 Closed	Level trigger off
4	DC1 Open	Level trigger off
5	ES Closed	Level trigger off
6	ES Open	Level trigger off
7	SEQSPVC1_FUSEF_3PH	Positive or Rising
8	SEQSPVC1_FUSEF_U	Positive or Rising
9	CCSPVC1_FAIL	Positive or Rising

Table continues on the next page

Channel	ID text	Level trigger mode
10	TRPPTRC1_TRIP	Positive or Rising
11	TRPPTRC2_TRIP	Positive or Rising
12	TRPPTRC3_TRIP	Positive or Rising
13	TRPPTRC4_TRIP	Positive or Rising
14	TRPPTRC5_TRIP	Positive or Rising
15	CONTROL OFF	Level trigger off
16	-	-
17	GNRLLTMS1_ALARM	Level trigger off
18	GNRLLTMS1_WARNING	Level trigger off
19	SCHLCCH1_CH1LIV	Level trigger off
20	SCHLCCH1_LNK1LIV	Level trigger off
21	CBXCBR1_CLOSE_COMMAND	Level trigger off
22	CBXCBR1_OPEN_COMMAND	Level trigger off
23	ARCDSARC1_ARC_FLT_DET	Positive or Rising
24	ARCDSARC2_ARC_FLT_DET	Positive or Rising
25	ARCDSARC3_ARC_FLT_DET	Positive or Rising
26	-	-
27	-	-
28	-	-
29	-	-
30	-	-
31	-	-
32	-	-
33	GOOSERCV_BIN 0_MASTER_TRIP 1	Level trigger off
34	GOOSERCV_BIN 1_MASTER_TRIP 2	Level trigger off
35	GOOSERCV_BIN 2_MASTER_TRIP 3	Level trigger off
36	GOOSERCV_BIN 3_MASTER_TRIP 4	Level trigger off
37	GOOSERCV_BIN 4_MASTER_TRIP 5	Level trigger off

Table continues on the next page

Channel	ID text	Level trigger mode
38	GOOSERCV_BIN 5_LOCKOUT_RESET	Level trigger off
39	GOOSERCV_BIN 6_AU_OPEN	Level trigger off
40	GOOSERCV_BIN 7_AU_CLOSE	Level trigger off
41	GOOSERCV_BIN 10_MASTER_TRIP 1	Level trigger off
42	GOOSERCV_BIN 11_MASTER_TRIP 2	Level trigger off
43	GOOSERCV_BIN 12_MASTER_TRIP 3	Level trigger off
44	GOOSERCV_BIN 13_MASTER_TRIP 4	Level trigger off
45	GOOSERCV_BIN 14_MASTER_TRIP 5	Level trigger off
46	GOOSERCV_BIN 15_LOCKOUT_RESET	Level trigger off
47	GOOSERCV_BIN 16_AU_OPEN	Level trigger off
48	GOOSERCV_BIN 17_AU_CLOSE	Level trigger off
49	-	-
50	-	-
51	-	-
52	-	-
53	-	-
54	-	-
55	-	-
56	-	-
57	-	-
58	-	-
59	-	-
60	-	-
61	-	-
62	-	-
63	-	-
64	-	-

3.4.3 Functional diagrams

The functional diagrams describe the default input, output, alarm LED and function-to-function connections. The default connections can be viewed and changed with PCM600 according to the application requirements.

The analog channels have fixed connections to the different function blocks inside the merging unit's application configuration. However, the 12 analog channels available for the disturbance recorder function are freely selectable as a part of the disturbance recorder's parameter settings.

Phase currents are fed to the merging unit from a current transformer or a current sensor depending on the order options. Residual current is fed to the merging unit either from residually connected CTs, an external core balance CT or neutral CT.

Phase voltages are fed to the merging unit from a voltage transformer or a voltage sensor depending on the order options.

3.4.3.1 Functional diagrams for local and remote control

The functional diagrams describe the merging unit's functionality in detail and according to the factory set default connections.

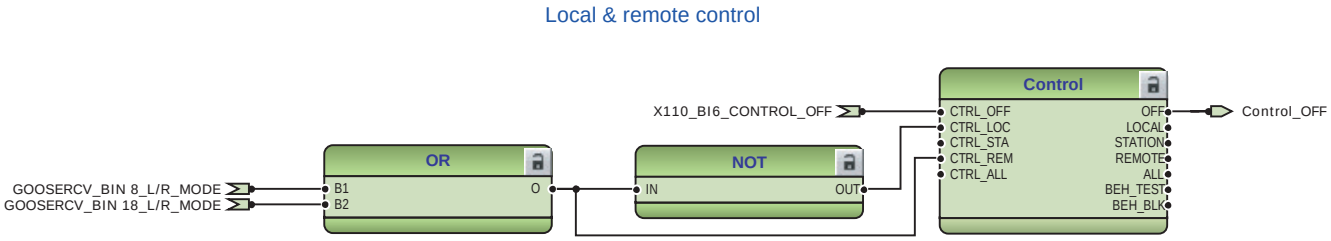

Figure 31: Local and remote control mode function

3.4.3.2 Functional diagrams for disturbance recorder

Output signals from the condition monitoring and supervision functions are routed to trigger the disturbance recorder or, alternatively, only to be recorded by the disturbance recorder depending on the parameter settings. Additionally, the selected signals from different functions are also connected to the disturbance recorder.

RDRE with AIM0013 MODULE option

RDRE with SIM0002 MODULE option

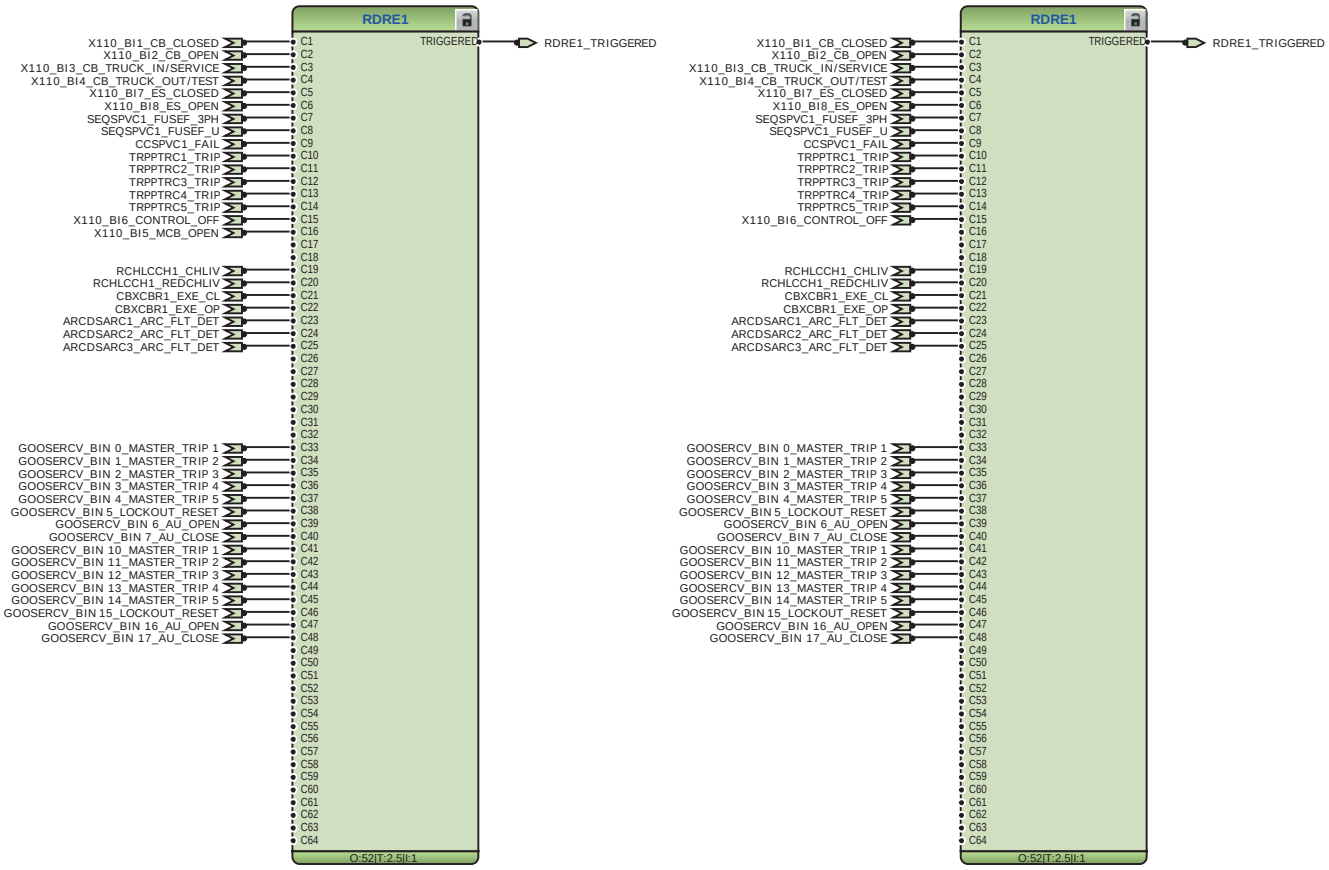

Figure 32: Disturbance recorder

3.4.3.3 Functional diagrams for condition monitoring and supervision

Failures in the current measuring circuits are detected by CCSPVC1.

The fuse failure supervision function SEQSPVC1 detects failures in the voltage measurement circuits. Failures, such as an open MCB, raise an alarm.

Circuit-breaker condition monitoring SSCBR1 supervises the switch status based on the connected binary input information and the measured current levels. SSCBR1 introduces various supervision methods.

Two separate trip circuit supervision functions are included: TCSSCBR1 for power output X100:PO3 and TCSSCBR2 for power output X100:PO4. Both functions are blocked by the master trips TRPPTRC1 and TRPPTRC2 and the circuit breaker open signal.

It is assumed that there is no external resistor in the circuit breaker's tripping coil circuit connected in parallel with the circuit breaker's normally open auxiliary contact.

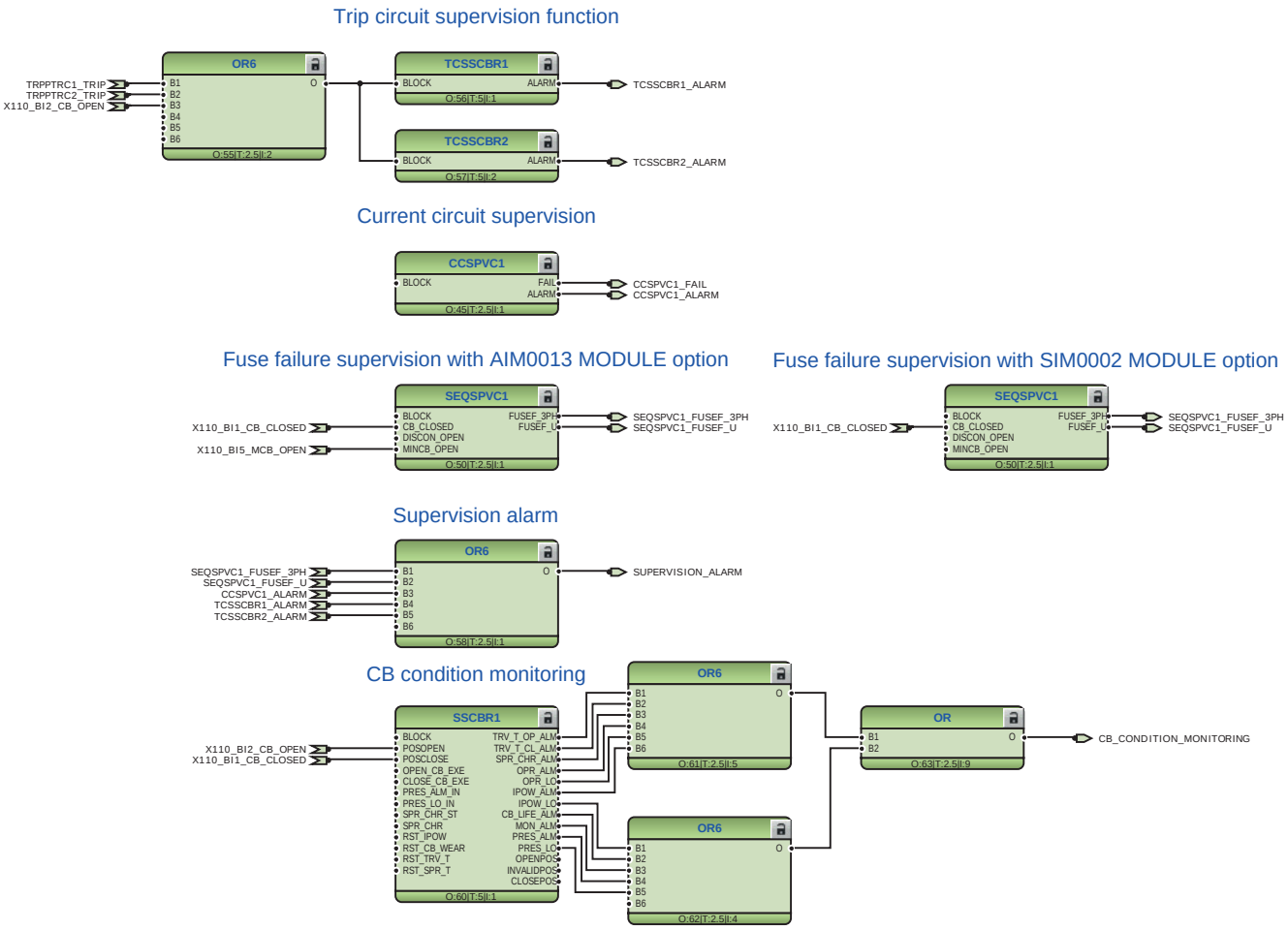

Figure 33: Current circuit and Fuse failure supervision functions

Three arc detection function stages ARCDSARC1...3 are included as an optional function. The arc detection offers individual function blocks for three arc sensors that can be connected to the merging unit. Each arc detection function monitors the light information from an arc and delivers a signal, if an arc is detected.

The output signals from ARCDSARC1...3 are connected to the disturbance recorder function block.

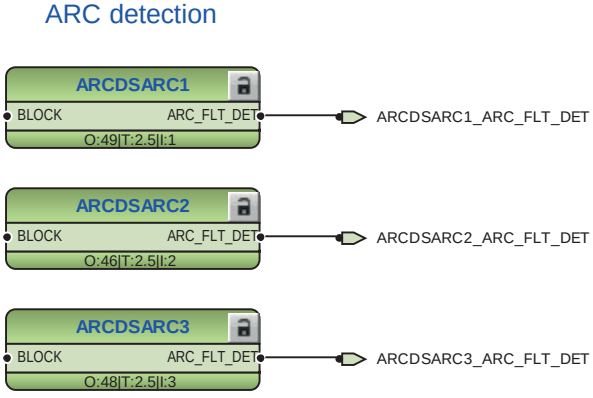

Figure 34: Arc detection function

3.4.3.4 Functional diagrams for control

DCSXSWI1 and ESSXSWI1 are of status only type. By default, the status only blocks are connected in the application configuration. The disconnector (CB truck) and line side earthing switch status information is connected to DCSXSWI1 and ESSXSWI1.

The circuit breaker closing is enabled when the ENA_CLOSE input is activated. The input can be activated by the configuration logic, which is a combination of the disconnector or breaker truck and earthing switch position statuses and the status of the trip logics. The circuit breaker opening command is given via communication by activating the AU_OPEN input. The circuit breaker closing command is given via communication by activating the AU_CLOSE input. The circuit breaker opening or closing command is blocked once the BLK_OPEN or BLK_CLOSE input has been activated by the Control_OFF signal. By default, Control_OFF is connected to X110-BI6.

The OKPOS output from DCSXSWI defines if the disconnector or breaker truck is definitely either open (in test position) or closed (in service position). This output, together with the earthing switch opening and non-active trip signals, activates the close-enabling signal to the circuit breaker control function block. The opening operation for circuit breaker is always enabled.

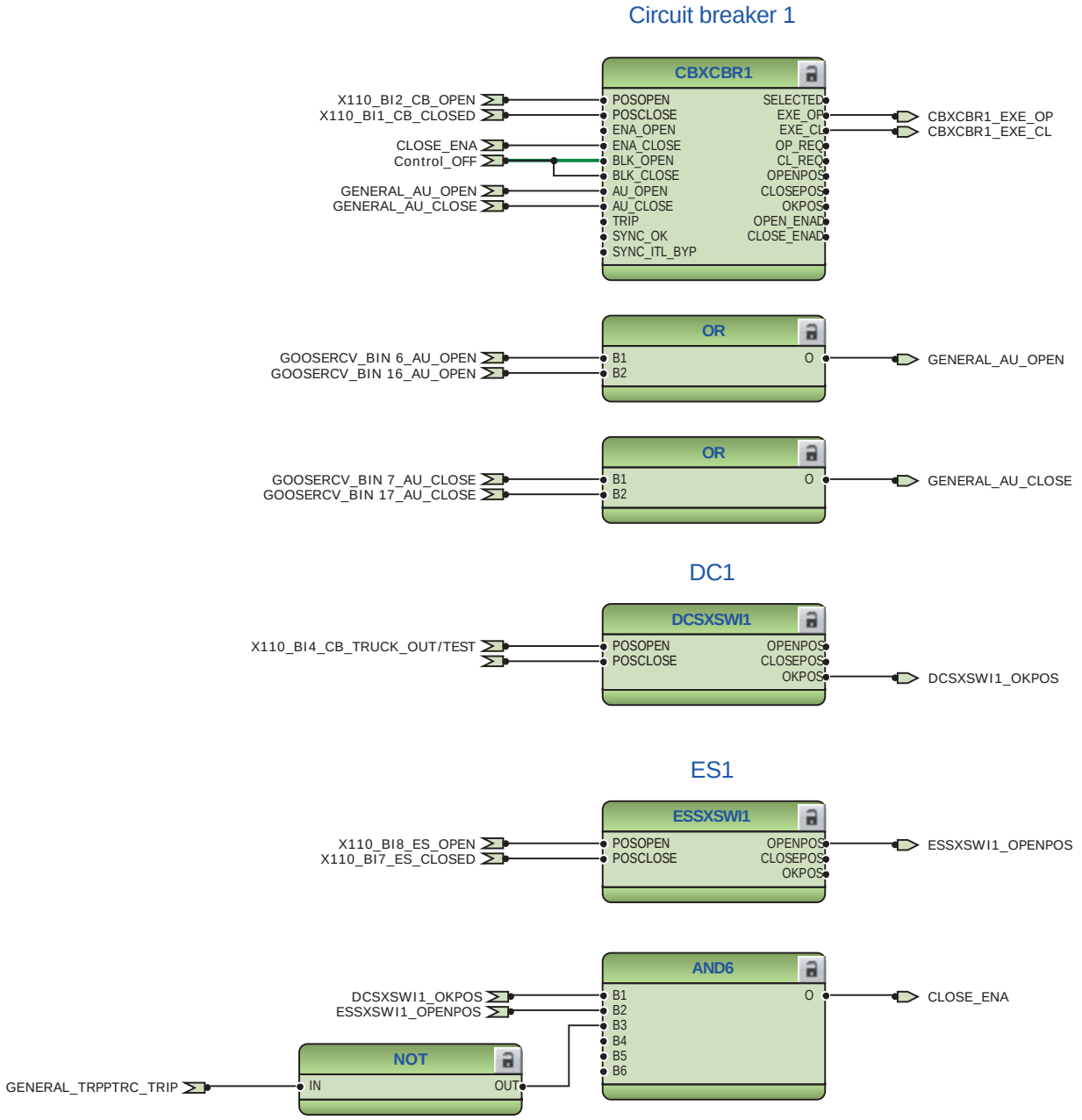

Figure 35: Control functions

3.4.3.5 Functional diagrams for master trip

The GOOSE binary input signals are connected to the five trip logics TRPPTRC1… TRPPTRC5. The outputs of trip logic functions TRPPTRC1 and TRPPTRC2 are available at binary outputs X100:PO3 and X100:PO4. The outputs of trip logic functions TRPPTRC3...TRPPTRC5 are available at binary outputs X110:HSO1, X110:HSO2 and X110:HSO3.

The trip logic functions are provided with lockout and latching function, event generation and trip signal duration setting. If the lockout operation mode is selected, the binary input `GENERAL_LOCKOUT_RESET` has been assigned to the `RST_LKOUT` input to enable external reset with the connected GOOSE signal.

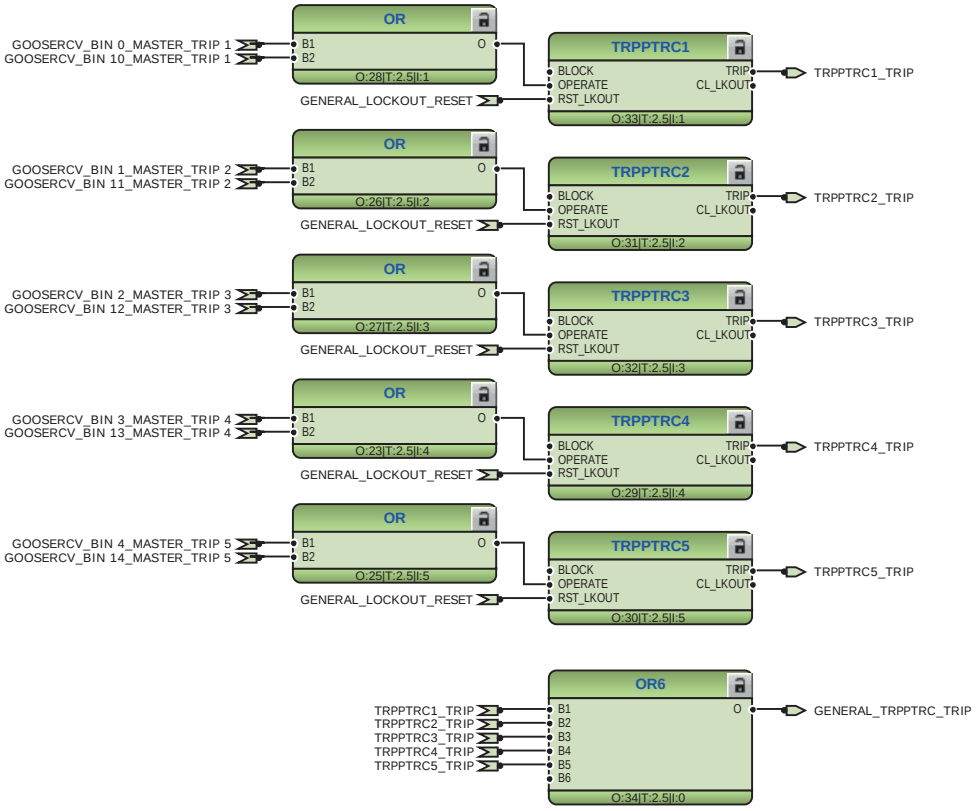

Figure 36: Trip logic

3.4.3.6 Functional diagrams for measurement functions

The phase current inputs to the merging unit are measured by the three-phase current measurement function CMMXU1. Similarly, the sequence current measurement CSMSQI1 measures the sequence current and the residual current measurement RESCMMXU1 measures the residual current.

The phase voltage inputs to the merging unit are measured by the three-phase voltage measurement function VMMXU1. The sequence voltage measurement VSMSQI1 measures the sequence voltage.

The measurements can be seen from the WHMI and they are available under the Measurement menu in the left navigation bar. Based on the settings, function blocks can generate low alarm or warning and high alarm or warning signals for the measured current values.

The frequency measurement of the power system FMMXU1 and the three-phase power and energy measurement PEMMXU1 are also available.

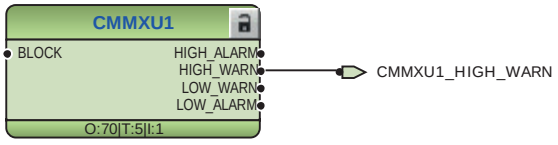

Figure 37: Current measurement: Three-phase current measurement

Figure 38: Current measurement: Sequence current measurements

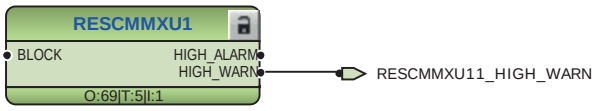

Figure 39: Current measurement: Residual current measurements

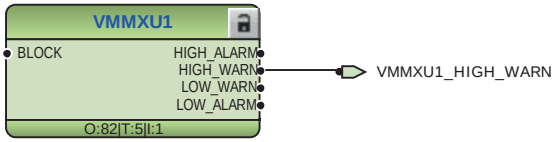

Figure 40: Voltage measurement: Three-phase voltage measurement

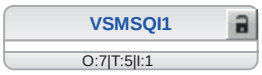

Figure 41: Voltage measurement: Sequence voltage measurements

Figure 42: Frequency measurement

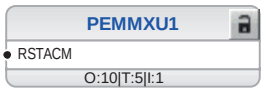

Figure 43: Three-phase power and energy measurement

3.4.3.7 Functional diagrams for I/O and alarm LEDs

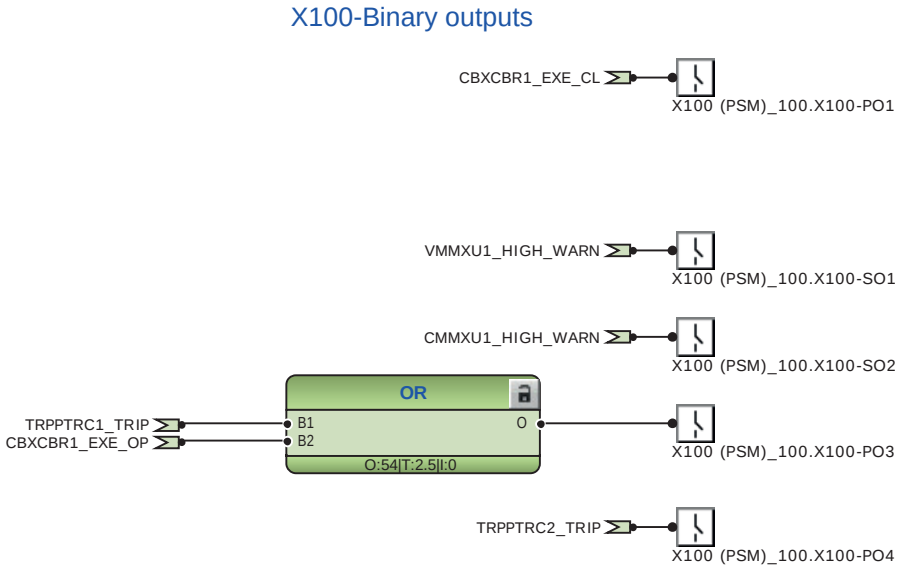

Figure 44: Binary outputs X100 terminal block

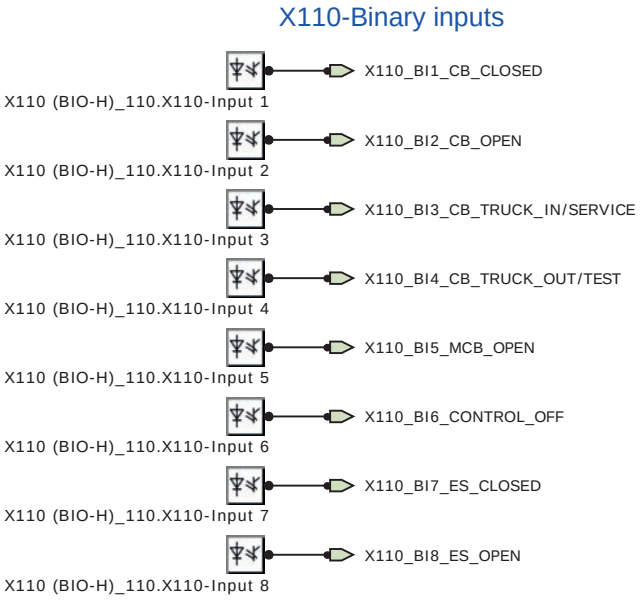

Figure 45: Binary inputs X110 terminal block

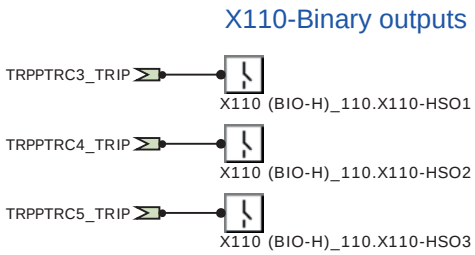

Figure 46: Binary outputs X110 terminal block

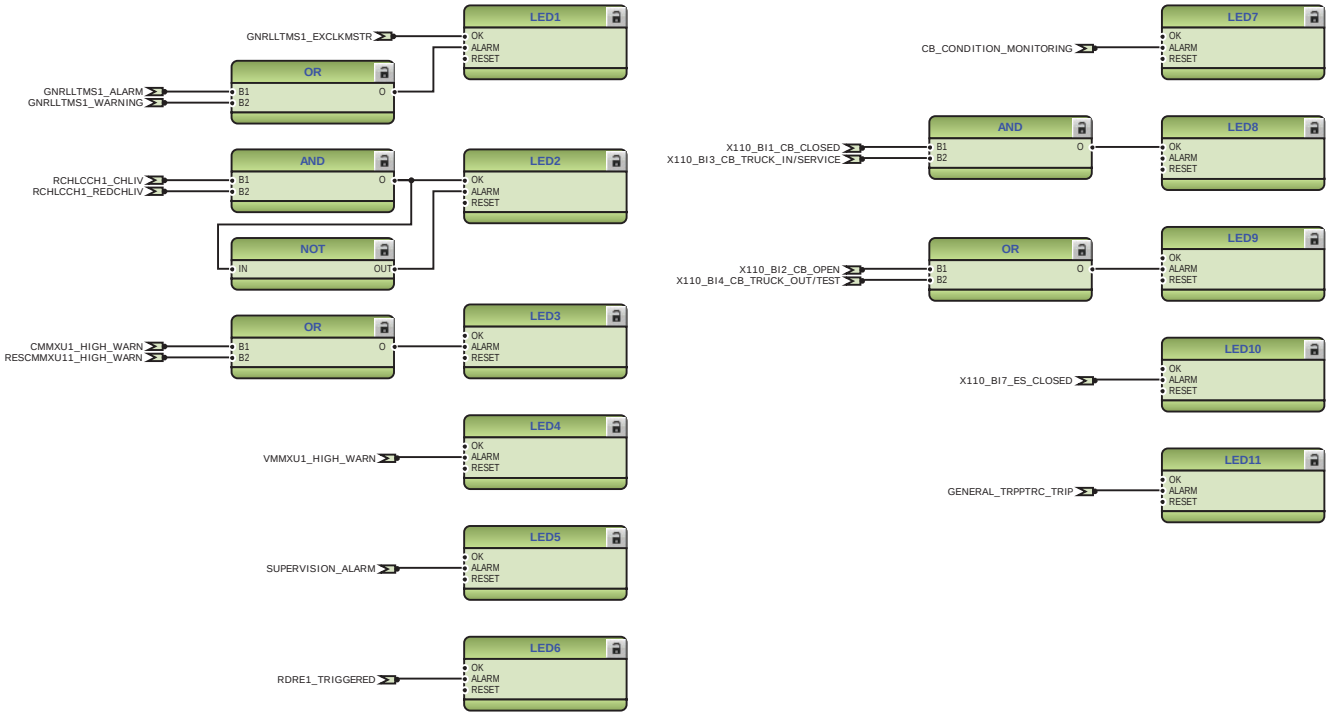

Figure 47: Default LED connection

3.4.3.8 Functional diagrams for communication

Figure 48: Default GOOSE binary inputs function connection

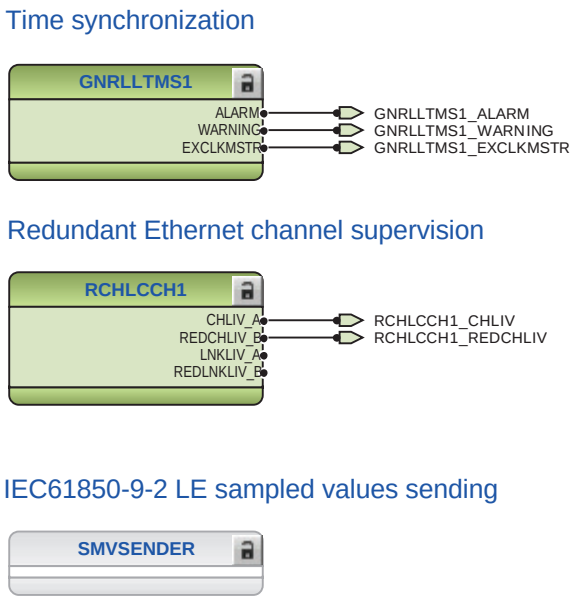

Figure 49: Default communication function connection

4 Merging unit's physical connections

4.1 Inputs

4.1.1 Energizing inputs

4.1.1.1 Phase currents

The merging unit can also be used in single or two-phase applications by leaving one or two energizing inputs unoccupied. However, at least terminals X120:7-8 must be connected.

Table 25: Phase current inputs terminals X120:7-12 with AIM0013

Terminal	Description
X120:7-8	IL1
X120:9-10	IL2
X120:11-12	IL3

4.1.1.2 Residual current

Table 26: Residual current input terminals X120:13-14 with AIM0013

Terminal	Description
X120:13-14	Io

Table 27: Residual current input terminals X130:1-2 with SIM0002/SIM0005

Terminal	Description
X130:1-2	Io

4.1.1.3 Phase voltages

Table 28: Phase voltage inputs terminals X120:1-5 with AIM0013

Terminal	Description
X120:1-2	U1
X120:3-4	U2
X120:5-6	U3

4.1.1.4 Sensor inputs

Table 29: Combi sensor inputs terminals X131-X133 with SIM0002

Terminal	Description
X131:4-5 X131:7-8	IL1 U1
X132:4-5 X132:7-8	IL2 U2
X133:4-5 X133:7-8	IL3 U3

Table 30: Combi sensor inputs terminals X131-X133 with SIM0005

Terminal	Description
X131 L1/A:1-2 X131 L1/A:7-8	IL1 U1
X132 L2/B:1-2 X132 L2/B:7-8	IL2 U2
X133 L3/C:1-2 X133 L3/C:7-8	IL3 U3

4.1.2 Auxiliary supply voltage input

The auxiliary voltage of the merging unit is connected to terminals X100:1-2. At DC supply, the positive lead is connected to terminal X100:1. The permitted auxiliary voltage range (AC/DC or DC) is marked on the top of the LHMI of the merging unit.

Table 31: Auxiliary voltage supply

Terminal	Description
X100:1	+ Input
X100:2	- Input

4.1.3 Binary inputs

The binary inputs can be used, for example, to generate a blocking signal, to unlatch output contacts, to trigger the disturbance recorder or for remote control of merging unit's settings.

Binary inputs of slot X110 are available with configurations C and D.

Table 32: Binary input terminals X110:1-10 with BIO0007 module

Terminal	Description
X110:1	BI1, +
X110:5	BI1, -
X110:2	BI2, +
X110:5	BI2, -
X110:3	BI3, +
X110:5	BI3, -
X110:4	BI4, +
X110:5	BI4, -
X110:6	BI5, +
X110:10	BI5, -
X110:7	BI6, +
X110:10	BI6, -
X110:8	BI7, +
X110:10	BI7, -
X110:9	BI8, +
X110:10	BI8, -

4.1.4 Optional light sensor inputs

If the merging unit is provided with the optional communication module with light sensor inputs, the pre-manufactured lens-sensor fibers are connected to inputs X13, X14 and X15. See the connection diagrams.For further information, see arc protection.

The merging unit is provided with connection sockets X13, X14 and X15 only if the optional communication module with light sensor inputs has been installed. If the arc protection option is selected when ordering a merging unit, the light sensor inputs are included in the communication module.

Table 33: Light sensor input connectors

Terminal	Description
X13	Input Light sensor 1
X14	Input Light sensor 2
X15	Input Light sensor 3

4.2 Outputs

4.2.1 Outputs for tripping and controlling

Output contacts PO1, PO2, PO3 and PO4 are heavy-duty trip contacts capable of controlling most circuit breakers. In the factory default configuration, the trip signals from all the protection stages are routed to PO3 and PO4.

Table 34: Output contacts

Terminal	Description
X100:6	PO1, NO
X100:7	PO1, NO
X100:8	PO2, NO
X100:9	PO2, NO
X100:15	PO3, NO (TCS resistor)
X100:16	PO3, NO
X100:17	PO3, NO
X100:18	PO3 (TCS1 input), NO
X100:19	PO3 (TCS1 input), NO
X100:20	PO4, NO (TCS resistor)
X100:21	PO4, NO
X100:22	PO4, NO
X100:23	PO4 (TCS2 input), NO
X100:24	PO4 (TCS2 input), NO

4.2.2 Outputs for signalling

SO output contacts can be used for signalling on start and tripping of the merging unit. On delivery from the factory, the start and alarm signals from all the protection stages are routed to signalling outputs.

Table 35: Output contacts X100:10-14

Terminal	Description
X100:10	SO1, common
X100:11	SO1, NC
X100:12	SO1, NO
X100:13	SO2, NO
X100:14	SO2, NO

Output contacts of slot X110 are available with application configuration B.

Table 36: Optional high-speed output contacts X110:15-24 with BIO0007

Terminal	Description
X110:15	HSO1, NO
X110:16	HSO1, NO
X110:19	HSO2, NO
X110:20	HSO2, NO
X110:23	HSO3, NO
X110:24	HSO3, NO

4.2.3 IRF

The IRF contact functions as an output contact for the self-supervision system of the merging unit. Under normal operating conditions, the merging unit is energized and the contact is closed (X100:3-5). When a fault is detected by the self-supervision system or the auxiliary voltage is disconnected, the contact X100:3-5 drops off and the contact X100:3-4 closes.

Table 37: IRF contact

Terminal	Description
X100:3	IRF, common
X100:4	Closed; IRF, or U_{aux} disconnected
X100:5	Closed; no IRF, and U_{aux} connected

5 Glossary

AI	Analog input
BCU	Breaker control unit
BI/O	Binary input/output
BO	Binary output
CB	Circuit breaker
DAN	Doubly attached node
DC	1. Direct current 2. Disconnector 3. Double command
DPC	Double-point control
EMC	Electromagnetic compatibility
Ethernet	A standard for connecting a family of frame-based computer networking technologies into a LAN
FIFO	First in, first out
FTP	File transfer protocol
FTPS	FTP Secure
GOOSE	Generic Object-Oriented Substation Event
HSR	High-availability seamless redundancy
HTTPS	Hypertext Transfer Protocol Secure
I/O	Input/output
IEC	International Electrotechnical Commission
IEC 61850	International standard for substation communication and modeling
IEC 61850-8-1	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2	A communication protocol based on the IEC 61850 standard series
IEC 61850-9-2 LE	Lite Edition of IEC 61850-9-2 offering process bus interface
IED	Intelligent electronic device
IEEE 1686	Standard for Substation Intelligent Electronic Devices' (IEDs') Cyber Security Capabilities
IP address	A set of four numbers between 0 and 255, separated by periods. Each server connected to the Internet is assigned a unique IP address that specifies the location for the TCP/IP protocol.
LAN	Local area network
LE	Light Edition
LED	Light-emitting diode
LHMI	Local human-machine interface
MCB	Miniature circuit breaker

Table continues on the next page

MMS	1. Manufacturing message specification 2. Metering management system
MV	Medium voltage
NC	Normally closed
NO	Normally open
PCM600	Protection and Control IED Manager
PO	Power output
PRP	Parallel redundancy protocol
PTP	Precision Time Protocol
RIO600	Remote I/O unit
RJ-45	Galvanic connector type
SAN	Single attached node
SMU615	Substation merging unit
SMV	Sampled measured values
SO	Signal output
TCS	Trip-circuit supervision
WAN	Wide area network
WHMI	Web human-machine interface

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